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SPRING MEETING PAPERS IN THIS ISSUE

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SPRING MEETING PAPERS

THIS country is now in a war of great magnitude and far-reaching results. It is a war of brains and has resolved itself into a contest putting the utmost demand on the ability of engineers to organize and direct the industries which constitute the vital forces of the nations involved. Two and one-half years of the war have emphasized this truth. One of the most potent requirements for a successful issue is an ample and sufficient output of war material from engineering workshops. To bring out the results of valuable experience in munitions manufacture, which has been obtained by many engineers through the period of war, and to make these results available to all, professional sessions of the Spring Meeting of The American Society of Mechanical Engineers will be devoted to the various phases of the subject. Papers to be presented at these sessions are printed in comprehensive abstract below.

Other important professional features of the Spring Meeting, to be held in Cincinnati, May 21 to 24, are sessions on Machine Shop Practice, Gas and Steam Power Subjects, and Protection of Industrial Workers and also a Joint Session with the National Machine Tool Builders' Association for the consideration of papers on Employees' Service Work and Industrial Education. Abstracts of papers to be presented at the first three of these sessions are also published in this issue. The topics at the Joint Session will be introduced in the form of addresses without previous publication.

MUNITIONS PAPERS

THE Committee on Meetings, in arranging for sessions at the Spring Meeting on the subject of the Manufacture of Munitions, desired to obtain a general discussion of the basic problems involved, which have to be met and solved to ensure success in the quantity production of arms and ammunition. The brief papers which follow are in the nature of introductory discussions, designed to draw out further discussions on such fundamental questions as Financing, Organization, Manufacturing Principles, Special Machines, Essentials for Quantity Manufacturing, Procuring Materials, Specifications, Limits and Tolerances, Gages and Inspection. The sessions will be entirely informal, and all members who have had experience in munitions manufacture are urged to attend and contribute to the common cause.

Following the papers is a bibliography of current articles on munitions production which have appeared during the past eighteen months.

MUNITIONS CONTRACTS AND THEIR FINANCING

By FREDERICK A. WALDRON, NEW YORK, N. Y.

Member of the Society

THE manufacture of munitions is a strictly engineering proposition in which the functions of the engineer dominate. Had engineering methods been employed in the initial stages of the work in the past two years, instead of "corner grocery" methods of beating down in price for the sake of letting the contract at an advantageous figure, the profits in many cases would have been far in excess of what they are today.

Few people realize the penetration of financing into the bone and sinew of our national existence. In the daily routine of life, with the majority of people receiving a stipulated income by the day, week, month or year, the intricacies and risks involved by those providing the money to pay this income are seldom if ever thought of.

The forces set in motion by signing a contract, large or small, penetrate and accelerate industrial and natural resources.

In the last two years wonderful progress has been made in the development of resources hitherto thought to be remote or inaccessible, and the education and training of men in the allied industries has developed at a rate heretofore unknown. Why this sudden development? Why such an exhibition of human energy, both mental and physical? It was dire necessity, and necessity knew no master.

Money or currency is the visible medium of exchange, and if there is no money or other recognized medium of exchange, man resorts to primitive methods and fights for existence.

With the advent of contracts amounting to millions, few manufacturers, if any, at the beginning of the war, fully realized the time that would be required to deliver the materials. Not only this, the amounts involved were staggering. It has now become customary to converse in terms of millions of dollars instead of dollars and cents. Further, the difficulties of the problems, such as sub-contractors failing to perform, the increased cost and difficulty of transportation, the obtaining of tools, equipment, materials, and labor, for the fulfillment of these contracts, were not anticipated.

With these conditions, which are now in retrospect, many industries are charging off deficits of considerable size to experience in the manufacture of munitions. Few have made fair profits. Some have made abnormal profits.

With the foregoing as a matter of history, the question as to how the Allied Nations obtained their credit would be extraneous to the subject. This brings the question before us for discussion as to how the contractor is to receive his money promptly and regularly for his work.

It is sufficient for the manufacturer to know that the work which he is to do will be regularly and promptly paid for, and any risks taken by him to produce in quantity within the time specified are to be amply protected by an advance of money sufficient to cover the expense of preparation.

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Undoubtedly the cause of failures in the delivery of munitions of sufficient quantity within the time specified, is directly traceable to the lack of judgment in the amount of money demanded as advance payment, combined with a lack of business and financial management.

If we review carefully the ratio of the amounts advanced to the total amount of the contract and its time of completion, it will be found that in no case has a sufficient advance been made to enable the contractor to finance this work on the same basis as he would adopt in the conduct of his regular business.

WHAT IS FINANCING?

Financing is providing the coin of the realm in adequate and opportune quantities for the purpose of obtaining an object desired. Where ready cash is not available, the usual way of providing the coin of the realm is by the issue of mortgages, bonds or notes, which are papers promising to pay at maturity the amounts advanced, with interest of course for the use of the money, payable at specified periods during the time for which the loan is made.

All mortgages, bonds or notes must have tangible and preferential security, rights, etc. These principles cover the salient points necessary for a government, corporation or individual to obtain the necessary amount of money to pay for the object to be obtained.

Documents given by the party wishing to obtain the object (called the Owner or Purchaser) to the party who is to provide the object (called the Contractor or Vendor) are in the form of leases, contracts, or purchase orders, supplemented by specifications and drawings, or samples of the object desired.

Prior to the signing and exchange of these documents, the money which the purchaser wishes to use to attain his object has been provided. Upon the signing and exchange of these documents, the details are planned for distributing this money in adequate and opportune quantities in order that the object to be attained may be completed as rapidly as possible and the contractor provided with sufficient funds to promptly and efficiently complete his work.

If a purchase order or contract exceeds a certain amount and covers a definite period of time, a bond is required in order to protect the purchaser.

On large munitions contracts, the bonds of sub-contractors are marshalled by the general contractor and deposited as security. This is to indemnify the purchaser against loss. In fact, the bond is the purchaser's insurance to secure him against failure to complete the work, or the dissipation of moneys paid by the purchaser to the contractor as an advance payment. A bond is also required by those financing the work.

ADVANCE PAYMENTS

1 When and how met
2 Amount in percentage of the total amount of the contract
3 Rate of liquidation
4 Interest charges.

PAYMENTS ON ACCOUNT

1 When to be met. Depends on:
- *a* Resources of contractor
- *b* Volume and rate of delivery of material
- *c* General progress of work
- *d* Complete information.

2 Amount of payments:
- *a* Purchase value less a certain percentage for reserve or adjustment at end of contract
- b A purchase value or agreed amount to liquidate advanced payments.

3 Type of payments:
- *a* Sight draft, check, notes or bonds.

FINAL PAYMENTS AND ADJUSTMENTS

1 Adjustment of percentage held back on part payments
2 Adjustment of debits and credits during the progress of the contract
3 Type of funds:
- *a* Notes, bonds, sight drafts, checks.

DISCUSSION OF ADVANCE PAYMENTS

In manufacturing and contracting requirements, it is a well-known fact that from three to five turnovers of inventory per year are essential to a reasonable profit.

The general contractor, on a large munitions contract, has to provide in turn advances not only to the sub-contractor, but he must also be able to take advantage of the market, and oftentimes buy materials long before they are required. He has also to meet the payments for materials of sub-contractors furnished long in advance of the time they are to be used. Then, again, contracts have been let to some small concerns who have failed to fulfill the requirements of the contract. This also applies to the larger sub-contractors and, as has been the case, it is necessary for the general contractor, in order to protect himself, to take control of the entire properties of the sub-contractor on an entirely different basis and under entirely different conditions. This involves delays not ordinarily estimated in the contemplation of the work to be done.

A further necessity for ample and proper financing during the progress of the contract, is that assembling contractors be supplied with a sufficient number of component parts of proper quality in order to complete the work.

It is quite possible (in fact, it has happened) that manufacturers of component parts have held up shipments awaiting payments on their materials. To my knowledge, this has involved at different times delays in the completion of work valued at from one to three million dollars over a period of time of from two to five weeks, which, if figured on the basis of six per cent, would mean a loss to the general contractor of from $4,000 to $12,000 on interest charges alone.

But, beyond all of this is the demoralizing effect on a sub-contractor and the discouragement which he experiences. This reacts upon the organization, and in a very short time the enthusiasm and efficiency of the personnel of the plant have rapidly deteriorated.

Then, again, the question of financing depends to a large extent upon the government with which the general contractor is dealing. With some there is no trouble, and businesslike methods are used in the handling of all financial transactions. There are others, however, that are exceedingly troublesome and irregular in meeting their financial obligations and, while they are good for the money obligated, the irregularity and slowness of payments oftentimes creates suspicion and distrust on the part of the manufacturer, with a corresponding demoralization.

After an observation and experience of two years in this work, the writer feels safe in assuming that an advance of at least 25 per cent is necessary and 33 1-3 per cent would

leave a sufficient margin of safety, with good management.

It is not necessary that all of this amount be paid upon the signing of the contract, but it should be available for drawing upon as occasion might require.

The rate at which advance payments should be liquidated is a matter which can only be adjusted to the requirements of the case in hand. A good rule to follow is to deduct from each invoice the same percentage of this invoice as would liquidate the advance payment upon the completion of the contract. It is customary, in some contracts, to deduct an additional ten per cent as an adjustment fund to protect the purchaser at the completion of the contract.

Interest charges are sometimes demanded on advance payments, but the usual practice is to dispense with this charge.

PAYMENTS ON ACCOUNT

Payments on account depend on the resources of the contractor, volume of business, rate and quality of materials delivered, general progress of the work, and complete audit information as to the financial condition of the contractor.

The amounts of these payments are generally made on the invoice value of the materials shipped, less deductions for the liquidations of the advance payments and insurance to the purchaser.

The types of payments usually made are either cash on receipt of the bill of lading or sight draft; or settlements at certain defined periods, either by the week, semi-monthly or monthly; sometimes, thirty days from the receipt of the invoice, bills of lading or inspectors' certificates.

Where the financial standing of the company is such as enables it to have cash on hand or available to conduct its business, payments are taken in bonds or short-term notes of the government for which the work is being done.

FINAL PAYMENTS

Final payments should be made as promptly as possible upon the completion of the contract. It is hardly possible, in the majority of contracts, to make these final payments promptly, as it oftentimes involves the adjustment of debits and credits for expenses on the part of the contractor and rejected work or spoiled materials on account of the purchaser. It is essential, therefore, in order to have a prompt adjustment, that a close check be kept on the progress of the work at all stages and a clear and definite method of maintaining records be kept by both the purchaser and the contractor.

The types of funds used in final payments are the same as those used for payments on account.

ORGANIZING FOR MUNITIONS MANUFACTURE

By ARTHUR L. HUMPHREY, WILMERDING, PA.

Member of the Society

THE task of organizing a plant to undertake the manufacture of munitions is one of many factors. In fact, organizing involves all of the items in the general list: specifications, materials, designing, limits, gages, inspecting, etc. The general success of the undertaking is dependent upon the perfection of the working organization, upon the selection and installation of adequate machines and other tools, and upon the careful planning of the work, which is not limited to that within the shop alone, but involves a consideration of the market, the purchase and delivery of supplies.

The financing accomplished, the task of organizing comes next in order. Their work done, the financial backers of the undertaking become impatient to see deliveries made because of their failure to understand the mechanical and human problems in the task of organizing, and a net loss is the result of insufficient time being allowed for perfecting the working organization, equipping for and planning the work. Haste makes waste in most affairs and it is not the exception here. A premature beginning may result in an encounter with conditions which will mean an entire revamping of the whole scheme—conditions which would have been determined and provided for had sufficient time been given for careful planning and making schedules complete in every detail from start to finish.

It is quite essential that an organization for the manufacture of munitions be built around a nucleus of men who have had experience either in munition making or in work of an allied character. With such a group as a basis, it is comparatively easy to place new men and ramify the organization into the various departments and divisions, each properly correlated with the other. It should be so arranged that each department acts as a unit within itself and attends to but one thing, such for instance as manufacturing the shrapnel time fuse and that alone.

Many operations in the manufacture of munitions cannot only be as well done by women as by men, but are better done by female help. These operations are such as involve light, delicate work, requiring deftness and dexterity in the use of the fingers. Therefore, such work should be segregated at every opportunity and the organization be made to include the requisite number of women.

The work to be accomplished is first revealed by the specifications submitted. Conferences between the engineers and shop foremen should be held at frequent intervals as the planning and scheduling progress in accordance with the results demanded by the specifications, and the whole problem should in this way be thoroughly "threshed over."

This problem of organizing is closely bound up with that of equipment. The condition of the machinery market and the urgency of the contract will determine largely the type of machines installed. In every case, where possible, automatic or semi-automatic machines should be given preference in order to get maximum accuracy with a minimum skill requirement on the part of the operators. This reduces materially the losses due to error of the individual. Careful consideration should be given to every detail of the manufacture, a thorough time study made, and the most logical sequence of operations worked up and scheduled before decisions are made as to the types of machines to be installed. Too much stress cannot be placed upon this feature, for any changes it may be necessary to effect after the machines have been ordered will result either in considerable loss or inefficient manufacture. Grouping of the machines should also be gone into very carefully to avoid unnecessary handling between successive operations.

Great emphasis must be placed on the necessity for a well-organized and well-equipped tool room. It is of paramount importance to have an unstinted supply of gages, jigs, machine fixtures and other special tools, for these are needed in great number in the manufacture of munitions. They are, in

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fact, indispensable to the successful quantity production of accurate work.

Also, upon the inspection department will depend the proper utilization of the gages supplied by the toolroom—in other words, the inspection department and the toolroom are links in the same highly important chain of accuracy. A carefully organized inspection force must check the product not only at the end, but at each successive stage of manufacture. The product must be checked not only for variations in dimensions but for chemical and physical properties as well. The personnel of the inspection force is of the utmost importance, for it is quite unwise to give the power of rejection to a group of uninformed inspectors who are lacking in judgment. And if power to reject be withheld, the inspection force might well be entirely dispensed with.

Other points of interest in this general connection may be found in the writer's paper on The Mobilization of Material and Industrial Resources, read before the Engineers' Society of Western Pennsylvania on May 31, 1916.

ORGANIZATION FOR MUNITIONS MANUFACTURE

By HARRY L. COE, BOSTON, MASS.

Member of the Society

I HAVE approached the subject from the viewpoint of a manufacturer already engaged in a metal-working business, and have tried to suggest some of the factors which he should consider if he expects to produce projectiles. Assuming that the manufacturer has ample financial resources, adequate equipment, a satisfactory source of raw materials, etc., what type of an organization is essential to the successful production of munitions; and among the various kinds of munitions, what articles can the particular plant produce economically?

Much time and effort will be wasted if this double process of selection is not given attention. The characteristic optimism and confidence of the American manufacturer, coupled with the strong desire to be of service to his country, or to make money, lead many firms into making persistent efforts to get munitions contracts which should, logically, go to firms of an entirely different character and facilities.

Before looking for a munition contract, there should be an honest self-analysis. It isn't a question of "can my shop produce this piece?" but "can it make this piece as well and as economically as anyone else?"

Many firms having a good manufacturing organization will feel that they require only a little additional equipment. To these people I say, "Beware!" Three years ago they might have had as good a chance of success as anyone, but today they will have to compete with the firms which have not only the organization but the proper equipment as well.

On the other hand, they may have a general equipment which can be adapted to munitions, but their shop and executive organization may not be trained to think and act along the lines of specialized mass production. And here again I say, "Beware!" Difficult, slow and expensive though it may seem to start from nothing and equip a complete munitions plant, it is much more difficult, slow, and expensive to develop and get into effective operation the organization which will make this kind of a business successful.

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CHARACTERISTICS WHICH MUNITIONS PLANTS LACK

We turn with pride to our great industries,—the steel corporation, our railroads, etc.—and feel that certainly the American genius and ability which has made them possible can turn out unlimited quantities of shells. And so they can, *if they have time*. Unfortunately for the manufacturer, this element of time is of the greatest importance to the fighting units. The advantage lies with the side which first gets the necessary supplies.

The big, centralized organizations are the result of a slow process of evolution, and while their working force may be constantly changing, one finds that the habits and traditions of the work are maintained, and it is this force—habit and tradition—which is entirely lacking in the munitions business. To produce shells economically, this force must be generated in and by the organization, which means embodying in that organization a certain proportion of picked men, chosen because they possess these habits, or who, because of their versatility and training, can quickly acquire them. Such men are not easy to find and the time it would take to get *enough* of them together in one place to make a large organization successful is almost a fatal handicap.

It would seem, therefore, that the greatest success would be obtained by comparatively small units specializing in one type of munitions. One may say, "Why not have a big shop departmentalized, with a case shop here, a shell shop there, time fuses or primers in another section, etc.?" Theoretically, this would be all right, but if one studies the organizations which have tried this in the past few years, he will find a tremendous amount of lost time, effort and money. In other industries where this principle has been successfully developed, I believe there will be found quite a percentage of men in each division who have grown gray-haired with years of service along that particular line.

This condition does not obtain today with respect to the munitions business. Before the present year the firms manufacturing projectiles in the United States were very few. The orders placed by our Government outside of its own arsenals were so small that even at the high figures paid they offered no attractions to anyone to develop a business along these lines. As a rule, the training in the arsenals has not fitted men to produce the best results under our existing industrial conditions. At the present time the arsenals are not letting any of these good men get away. In general, the attitude of the War Department has not encouraged the development of this industry except in the cases of a few manufacturers, as mentioned above. The result is that there is a very limited field from which to draw either workmen or executives "skilled in the art."

It would seem, therefore, that the manufacturer must build an organization around such of his men as possess the proper habits and training, and they in turn will have to see to the development of the manufacturing units. Here, again, large and complicated units do not develop rapidly, and in them mistakes are tremendously expensive and slow to correct.

The manufacturer should therefore take stock of his organization carefully. If it does not contain men whose habits of thought and training are consistent with specialization of processes and mass production, it lacks one of the prime factors in successful munition manufacture.

ADAPTABILITY OF PLANT TO PRODUCT

If, on the other hand, the organization *is* of this type, he should look carefully over the wide range of articles classified

as munitions and select something which is as similar as possible to his regular product in size, material, and general nature.

We hear of gray-iron foundries making strenuous efforts to get contracts for producing cartridge cases, when the nearest thing they have to a press is a plate-molding machine and they never had an opportunity of running to capacity on a single pattern for more than a few days at a time. Needless to say, if such people are so unfortunate as to get a contract, it is almost certain to prove an expensive failure for them and may result in a serious shortage of supplies for the fighting line.

Assuming now that there is an organization which is accustomed to specialization and that a type of munitions adapted to the available equipment has been selected, what subdivision should be made in the organization and what functions should be performed by each?

In the first place, it is futile to try to handle a projectile department as an appendage to some other part of the business. It is a business in itself and its success or failure will probably depend on the completeness with which every detail is worked out and checked.

This is a product in which duplication inside exceedingly small limits is essential. Moreover, if one agrees with the theory of specialization mentioned above, the type of munitions manufactured will be limited to a few pieces, or even to a single piece, of the same nature. The size of the order should be large enough so that even the smallest working unit —man or machine—can be employed constantly on the same operation. Under such conditions no detail is so small but that it pays to give it careful attention. Every motion will be repeated many times an hour, and the expense due to trivial losses will soon reach large proportions. Realizing this and knowing that this is a temporary business, many firms have gone outside of their regular force and employed special managers to look after their projectile manufacture. This has been their sole function and the arrangement was terminated when the order was completed.

The internal mechanism of the organization, then, might be classified somewhat as follows:

1 General Service Department
2 Diplomatic Staff
3 Production Department
4 Inspection Department

1 General Service Department

Under the General Service Department, we find

a Records and accounting (with special prominence given to control of manufacture rather than to details of cost finding)
b Purchasing and stores organization
c Designing, drafting and experimental development
d Protection and safety (with special reference to destruction by representatives of the enemy's government and to the safeguarding of unskilled workers).

With reference to these general departments, it may be safe to modify our general principle of entirely separate organizations. Whether or not these departments are combined with the existing departments employed in similar work will depend somewhat on the volume of the work both in the normal business and in the munition contract, as well as on the physical layout of the plant. In most cases it is possible so to plan that this work will follow the practice developed for the regular business and can be absorbed by the departments already doing this kind of work.

With reference to the purchase and stores of the department, there are no special features which differ to any radical degree from ordinary practice.

2 Diplomatic Staff

While this organization will be small, it is none the less important. If the munitions are for a foreign government, there will undoubtedly be foreign representatives stationed at the plant as receivers. These men are not accustomed to our methods. Their temperament is entirely different from the people we are ordinarily meeting. Possibly they do not speak our language. If sufficient attention is given to them, and their points of contact with the organization limited as far as possible to a few chosen men, it will be much easier to reach a practical working basis and to prevent expensive and often unnecessary misunderstandings and delays.

This department is responsible for seeing that these receivers are provided with the information they desire and that it is presented to them in such a way that they get a correct impression of the conditions. If they appreciate the difficulties which may be arising and the action the organization is taking to eliminate causes of trouble, it naturally affects their attitude toward the plant.

The diplomatic staff sees to it that any instructions issued by the receivers are transmitted to the proper department so that they go into effect.

Through this department, the shop can approach the receivers for information or rulings on conditions which may not be clear.

Even in the cases of work for our own government, I believe such a department is advisable. The fewer people who have official relations with these receivers, the less the chance of contradictory instructions or of false or unnecessary information or misunderstandings.

3 Production Department

Under the Production Department comes

a Maintenance of equipment
b Operation of equipment
c Selection and training of workmen
d Tool and gage production
e Establishment and operation of wage payment and penalties systems

This department is responsible for maintaining production and developing economy, and has full control of all agencies which bear directly on the operation of equipment.

Maintenance of equipment has been included under this department for two reasons: First, it brings the time element of repairs largely under its control. Much loss of production can be avoided by a careful and frequent inspection of machines and transmission. A few hours in adjusting may save days of shutdown later. And, second, because the men who make up the maintenance crew are usually the general group of millwrights who see to the location and moving of equipment, which again is a direct corollary of production. When breakdowns occur, operations have to be readjusted and it is often more economical to take an idle machine out of a battery and replace with a spare than to interrupt the flow of product. Such work is obviously up to the repair gang.

In this connection I am inclined to think that twenty hours per day is about the economical limit to run machines under the conditions of forced production usual on this work. The

remaining four hours for repairs is most excellent insurance.

Having given the production chief the means of supplying his working force with equipment to use, we must turn to a study of the workers.

Because of the difficulty of getting skilled mechanics, it has been necessary to develop that type of an organization which can produce results with the average workman in the shortest possible time. This is one of the reasons why it is well to subdivide the operations into simple elements and eliminate complex machines. Because of the very nature of the class of workmen available, it is necessary to make the most out of a continually changing force. This has been done successfully by selecting from the better grade of men a class which might be called *tool setters* or *machine starters*, and giving them charge of a battery of machines. This builds up a secondary line of defense, as it were, and it is possible to develop a fairly permanent organization of this kind of men. Behind these machine starters come the group foremen, assistant superintendents, etc.

For somewhat the same reasons the tool and gage manufacturing department is made a part of the production chief's organization. I say tool and gage *manufacturing* department instead of tool room advisedly, for it has to be a real manufacturing department with the demand for flat cutters, boring bars and heavy supplies of special tools which immediately occurs when one starts to reach maximum output on single-operation machines. The good tool maker is not as a rule a production man and it is a difficult thing to get a tool room into the spirit of manufacturing.

The method of wage payment for all these men is immaterial provided a maximum incentive is given to each man. Personally, I am in favor of a thorough piecework system, as it is simple for the workmen to understand and not expensive to operate. However, premium or bonus plans are all right if the rewards are immediate. The setting of standards is an important part of the wage basis and the opportunities for the competent operation and time-study man are wonderful. He, too, is part of the production chief's organization.

In this connection, while in general the theory of penalties is not desirable, it has been found that it is a good balance wheel to the continuous insistence put on production, especially where the workmen are not trained in the true spirit of machine shop existence and often are only transients with very little interest in the quality of their work.

4 Inspection Department

The work of the Inspection Department comprises

a Inspection of operations
b Intermediate inspection
c Final inspection

To some it may seem that at least part of the inspection organization should be directly under the chief of production: for example, the first or operation inspection which occurs between each operation. I believe, however, that better results and a more consistent and thorough inspection will ensue by creating a staff of inspectors responsible to their own chief to handle all inspections wherever they occur. It is easier to train men for these jobs and instil into them the necessary standards of work and habits of thought and action if they are included in a branch of the organization which is all their own.

Assuming that the complete inspection is organized into a department of its own, it may well develop according to the following scheme:

If the work has been subdivided so that operations occurring on individual machines are simple, it is possible to station back of each group of machines an inspector or inspectors and gage every piece for the controlling dimensions. We might class these inspectors as *operation inspectors*. It is their duty to see that each piece produced falls inside the tolerances which are allowed.

As the work progresses and a series of operations are performed upon a piece, it is often found desirable to have an *intermediate inspection*, as in many cases the later operations materially change the form of the piece so that it is impossible to check the work previously done. It is usually found desirable to set aside a certain part of the shop for this purpose and have all the product delivered to the inspection room.

This intermediate inspection is a general overall check on the production reported by the operation inspectors. The advantages are obvious when considered from the payroll point of view.

When a piece is finally finished and ready for presentation to the receivers, either of our own government or of a foreign government, there should be organized a thorough *final* inspection. Under this final inspection, all dimensions possible are checked and in general the same procedure as may be instituted by the receivers is followed out. In case the product does not come up to the standard, it is either sent back for repairs or else set aside and presented as a special batch with full explanations to the receivers. In this way the shop establishes a very desirable basis of fair play with the receivers and, as a usual thing, the policy results in the granting of special limits to cover slight deviations from specifications, which, if sent through with the other work, might arouse suspicion and work to the detriment of the shop.

In connection with the inspection organization, it is very necessary that an ample gage-checking force be organized. All working gages should be checked at least once a day and, in case of some of the finer type of gages, it may be necessary to check oftener if the standards are very exacting.

PROCURING SPECIAL MACHINES FOR MUNITIONS MANUFACTURE

By H. V. HAIGHT, SHERBROOKE, QUEBEC

Member of the Society

In asking for an introductory paper on the subject of the manufacture of munitions the Committee on Meetings suggested that the writer might "analyze the different types of machines required and indicate whether it is better to buy them or to make them."

As no two manufacturers of munitions follow the same methods or use the same machines, any opinions the writer may advance must be based on his own experience or observation and will be subject to confirmation or modification when compared with the experience of others. A few words as to the basis of the writer's experience will, therefore, be in order.

The firm with which the writer is engaged is machining and assembling the 18-lb. British shrapnel and the British 8-in. howitzer shell. Under the plan of organization of the Canadian Imperial Munitions Board, the work is all sublet by the board. The contractor for machining and assembling

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shrapnel, for example, is furnished with forgings for the bodies, with finished component parts such as disks, sockets, copper bands, tubes, tin cups, bullets, etc., and with the other materials required such as resin, solder, paint and shipping boxes. The following notes, therefore, cover only the machining and assembling of the above two sizes of shells which will be taken up separately. In addition to the experience mentioned, the writer has visited many shell shops both in Canada and the United States.

EIGHTEEN-POUND SHRAPNEL

When undertaking the first contract for shrapnel our firm had a machine shop which could be converted to shrapnel production and an experienced working force. As shrapnel production increased and as the regular work picked up, additional machines were purchased or made, until all the regular tools had been withdrawn from shrapnel production. In many cases these regular machines were withdrawn because required for producing the regular product; but there was the additional reason that for four-fifths of the operations the new tools purchased or made were more productive than the regular tools used at first. Our experience, therefore, has covered the use of standard machine tools, special purchased machines and special machines made by ourselves.

The following notes relate to the principal operations on the shrapnel and the machines which our experience shows were the best to use. Fig. 1 shows the shell at several stages and the numbers indicate the operations described below.

1 *Cut off open ends.* Standard 4-in. cutting-off machines with air expanding mandrels. Production 900 in 8 hours. We also tried a special machine to cut off both ends at one setting and another machine of the type of a pipe-threading machine, but both proved failures and were returned to the makers. On the regular machines the air mandrel is preferred to the universal chuck as it is much quicker and costs less to keep in repair.

2 *Rough turn body.* We used at first heavy 24-in. engine lathes, 24-in. Gisholts, Lo-swing lathes, etc., with fair results, but we are now using single purpose lathes of our own make which produce more work and are much simpler to keep in repair. These lathes have cast iron spindles, $6\frac{1}{2}$ in. in diameter in the front bearing, with driving gear integral with the spindle. They have tight and loose pulleys on the back-gear shaft, thus eliminating countershafts with their troubles. The feed is by belt, eliminating feed-gear troubles. The work is chucked on an air expanding mandrel and turned with a bar cam to give the necessary enlargement at the open end of the shell for the subsequent bottling.

3 *Rough face base.* We have used 36-in. engine lathes, 42-in. and 60-in. vertical boring mills, 36-in. planers, 30-in. planer-type millers, etc., on this work, but have abandoned them all for 4-in. standard cutting-off machines. On milling machines the tool upkeep is too great, on planers the work is hard to hold, on planers and boring mills the intermittent cut is hard on the machines and on all except the cutting-off machines, the labor cost and upkeep are too high. On the cutting-off machines the regular universal chuck is omitted and a plain hinged chuck used, as a universal chuck will not stand shell work. The regular cutting-off tool blocks are replaced with a tool block to hold a facing tool. When the countershaft clutch pulleys give out, they are replaced with tight and loose pulleys. Each man runs two of these machines.

4 *Finish face and turn base.* Standard 16-in lathes, with air collet chucks supported by steady rests, give satisfactory service on this operation. Only hand feeds are used.

5 and 6 *Rough and finish bore.* It has been found best to rough bore on one machine and finish on another. Turrets are not desirable on shell work, where they can be easily avoided. We used a well-known make of turret lathes on this work, but they proved pretty light and required considerable repair. They were eventually withdrawn for regular work and replaced by special boring lathes of our own make, in which the work is held inside the spindle by an air collet chuck. Two different feed mechanisms are in successful use, one a central rack with power feed and air return, the other a crank and "Scotch Yoke" with hand feed. Another Canadian munitions plant made very successful boring machines from gasoline engine patterns. We built a double spindle lathe for this work but it proved a failure.

7 *Rough band groove.* This work is being done on cutting-off machines and also on lathes of our own make. In both cases

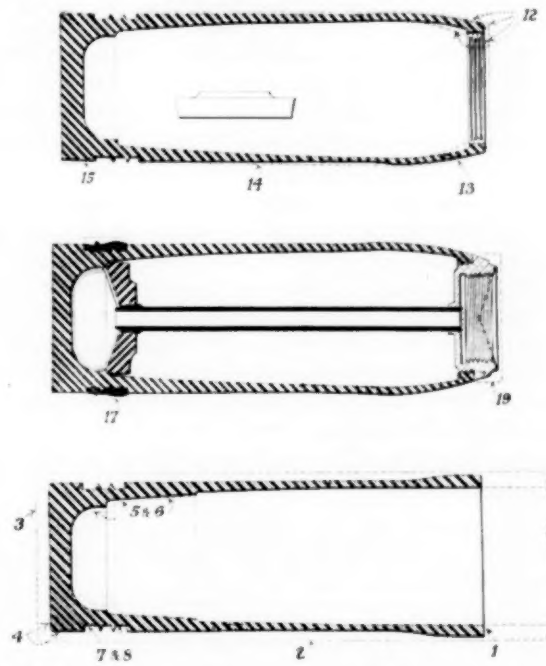

Fig. 1 Index of Operations of Machining Shell

the work is held in push-out air collet chucks. No longitudinal feed is required and only a hand cross-feed.

8 *Finish band groove.* This consists of undercutting the edges and forming the waved ribs. Potter and Johnston automatics are in successful use and stand up well. It has been found, however, that a man can do more work on one machine than he can on two or three, so the automatic feature is of no use on this work. Regular 20-in. engine lathes with special fixtures, and simple lathes of our own make with similar special fixtures, are now preferred as they produce rather more work. This is the only operation on which universal chucks are still used, but they will probably be superseded by air chucks. Two different purchased waving machines, built for this purpose alone, were tried but proved unsuccessful.

9 *Harden.* We used at first muffle furnaces, with cast-iron pot muffles holding eight shells, but now we use large semi-muffle furnaces, holding 50 shells. The furnaces are built to designs furnished us by another shell manufacturer, but appear to be copied from a commercial furnace. We used pyrometers at first, but now the operators go by color. An "Irite" pyrometer is used to train new men.

10 *Bottle.* The noses of the shells used to be heated by dipping in a pot of lead. This was rather expensive in the use of lead, and also gave a little trouble from lead poisoning. The present method is to heat in an oil furnace having holes through which the shells project into the furnace. A water-jacketed front was tried, but fire brick with iron thimbles has been found better. We built these furnaces after the style used in another shell shop. The bottling presses used at first were air presses which we made ourselves from drill sharpeners, but the present practice is to use geared crank presses which are purchased. After bottling, the shell is put back in a similar furnace to anneal the nose.

11 *Shot blast.* The regular foundry sand blast was used at first, but present practice is to use a small shot-blast machine of our own make. This has two jets, one of which cleans the band groove and the other the base. The shot blast gives practically no dust, and can be used anywhere in the shop.

12 *Turn and thread nose.* This requires a fairly heavy turret lathe, and we are using both 24-in. engine lathes, and also single purpose lathes of our own make, both of which are equipped with turrets. We prefer the latter lathes as they take the work inside the spindle and eliminate the steady rest. Air collet chucks are used. This is the only operation on the shrapnel where a turret is used and this requires five holes of the turret.

13 *Grind nose and* (14) *Grind body.* Standard grinders, slightly modified for the wide wheels used on shell work, give satisfactory results, as do also special purchased shell grinders. The grinding machine manufacturers, of all the regular machine tool builders, come out with the greatest credit from the viewpoint of shell production. In most other cases, the shell manufacturers themselves have built more suitable machines than either standard or special machines built by the machine tool manufacturers.

15 *Grind base.* Simple machines of our own make give good results.

16 *Press copper band.* Two different hydraulic hand presses, both designed and built by other shell manufacturers, are giving good results on this work.

17 *Turn band.* A heavy engine lathe with special equipment and an air collet chuck gives good results, but costs more money than a very good special band turning lathe, built by another shell manufacturer.

18 *Fill.* This is nearly all home-made equipment and hardly requires detailed description here.

19 *Turn socket.* A 16-in. engine lathe is heavy enough for this. A clutch on the back gear is convenient. A turret is not desirable.

20 *Paint.* We use with satisfaction a small portable machine of our own make, driven by a 1/6 hp. motor.

The foregoing does not cover the use of purchased single-purpose lathes, of which there are now a large number of designs on the market, but from experience with three or four types of these on 8-in. shells, it appears that they should give good results on shrapnel work. The features they should have would be a large spindle, 4-in. to 5-in. diameter, with hole at least 1 3/16-in., strong drive and feed, a good feed-engaging clutch, or better still a drop worm. The countershaft should have tight and loose pulleys, though the use of air chucks will largely eliminate countershaft troubles, as it is not necessary to stop to change the work. It is better, however, to have tight and loose pulleys on the headstock and eliminate the countershafts, as they take up so much room overhead that it is difficult to group the machines to best advantage. The elimination of countershafts also reduces the cost of belting, which is quite an item. A special point for consideration is the depth of dovetail on the carriage, for the cross slide. This should be $1\frac{1}{8}$-in. to $1\frac{1}{4}$-in. deep, but there are at least two of these lathes on the market with dovetail $\frac{3}{8}$-in. to $\frac{1}{2}$-in. deep, and a taper gib. The very small surface is not sufficient to resist the side strain of a cam, which is used on two of the operations, and the height is not sufficient to use a straight gib with set screws. It is usually necessary to replace the regular cross slide with a special cross slide, and when doing so it is much simpler to use a straight gib with set screws, rather than a taper gib.

To sum up, a manufacturer starting to make shrapnel would be well advised to consider the following suggestions:

a Do simple operations and use simple machines. Do not try to do several operations at one setting, and do not buy automatics, turret lathes or other complicated machines.

b A pretty safe and satisfactory plan is to get a quick start at some fraction of full intended capacity and to add equipment and build up production after some experience has been gained.

c Suitable purchased machines for making a quick start would be regular cutting-off machines, regular engine lathes 16-in. to 24-in. swing, simple single-purpose lathes, regular or special grinders and such special machines as bottling presses, band presses and band lathes.

d It will be worth while to consider the organization of a lathe building department to supply many of the machines required to increase the capacity. This department might also undertake the making of air chucks, waving devices and other special attachments, and thus relieve the tool room. Later, this department would become a repair department, which is an important and busy department when work is being pushed day and night.

[The author concludes his paper with a brief description of the operations on 8-in. howitzer shells.]

PRACTICAL WARTIME SHELL MAKING

BY LUCIEN I. YEOMANS, CHICAGO, ILL.

Member of the Society

So many utterly foolish statements have been offered the public in regard to the manufacture of munitions and the possibility of this or that automobile factory or implement works, or other equally ill-adapted shop, being turned upon very short notice into a shell factory, that it seems well to consider of how little value for the manufacture of munitions is the present equipment of the average shop.

It should be emphasized that outside of the already existing munitions plants, the old equipment which manufacturers brought to the new business of shell making consisted mostly of their money, their credit, and the nucleus of an organization. Even the old floor space was infrequently used. The machinery and tools were more than ninety per cent new and it is significant that the greatest success has been made by those companies which were not even owners of machine shops of any kind.

It is well for the mechanical engineers and the manufac-

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turers to review carefully accepted methods of munitions production and to ascertain just what time-honored precedents may be abandoned, what "red tape" may be cut, what traditions of the mechanic arts are sacred but unnecessary, where the corners may be cut and the result attained economically, directly, and without delay.

It would seem ridiculous to construct an office building of steel and terra cotta for the field headquarters of an army division, but we see nothing strange in the equally ridiculous proposition of a nicely built permanent factory for the comparatively simple operations of machining shells.

There is a strange twist in our mental conception which permits an engine for one purpose to be nicely housed in a pressed-brick and tile-lined structure, while another equally expensive and nicely made engine may be properly located on the open deck of a vessel, entirely unprotected from the weather. It is the same deference to tradition that makes us assume that machine tools must be guarded from every exposure, and we fail to see readily that their performance would be equally good for unusual service if they were heavily coated with rust on every idle surface.

The suggestions made here for emergency factory construction are to be understood as applicable strictly to emergency conditions and to meet a demand for an unusual amount of ammunition with the least possible delay and in no way as suggestions for permanent, private or Government arsenal construction.

First must be considered locality with reference to labor supply and transportation. Within easy reach of all our large centers of population may be found level, unoccupied, naturally well-drained acreage that is suitable for the purpose and that is gridironed by railroads. These are the sole requirements for such a plan.

The essential difference between this method and the conventional one is in the assumption that this particular machine work is no more an indoor occupation than is carpentry, brick laying, car repairing, or structural ironwork, and that in such emergency it should promptly be decided that outdoor equipment is satisfactory.

Final inspection, cleaning, painting, tool making, etc., would be provided for in fully enclosed buildings at the delivery end of the plant; but the large part of the work would be performed with the lightest kind of shelter over machines, operators, and transfer track, and in the opinion of the writer circumstances would not always justify even this.

The dimensions of the plant should be determined by the size of shell to be manufactured, and units of a given hourly capacity would be located between, and perpendicular to, two lines of railroad siding at the ends of the plant. One track would be entirely a receiving track and the one at the opposite side a shipping track. The distance between the tracks would represent the proper length of each unit to avoid congestion and afford the simplest movement and transfer of product.

The number of units required, as so determined, would establish the other general dimension of the plant.

Assuming that the shell was to be the well-known British 9.2-in. high-explosive and the required output 250 per hour, the general dimensions of the plant would be approximately 1000 ft. long by 300 ft. wide, and it would contain six units each capable of producing 42 shells per hour.

Each unit, commencing at the rear of the plant, would start with an unloading platform and extend in a double row of opposed machines for the different operations toward the finishing end, where the machinery installation would be replaced by hand operations and inspection, to the packing and shipping track.

From the end of the machine installation to the finishing end a single-story shelter would be built to house these operations and also the tool maintenance sections.

All machine tools would necessarily be horizontally belted, but since space is not considered, the convenience of having all transmission machinery within easy reach is a consideration.

In the construction of the plant, lines of concrete piers would be located to carry the line shafting, storm water drains would parallel the lines of piers, concrete foundation walls for the machine tools would come next, and transfer tracks intermediate the machine foundations.

Throughout the length of each machine-foundation wall would extend a cutting compound drain to a sump and pump at the end of the line or at intermediate locations. From each concrete pan under or at the machines would extend a chip channel, having a slightly raised bottom, connecting with chip tanks sunken in the ground and covered, but readily removable by the cranes.

Between each two rows of machines would be an industrial railway upon which would be operated platform cars for transfer. At each machine would be car-floor-height platforms from and to which all tools and material would be transferred.

Such a complete plant could be erected and operated to capacity within 60 days from the time authority was given to build it.

The purpose of this paper is to invite discussion, suggest a practical departure from the conventional and present a method of emergency construction that it is hoped will be of some benefit.

A complete series of machines for all shell-making operations could be designed along lines that would permit of their construction in immense quantities within 30 days from the time when the necessity for them arose, and at a rate of output that would supply any conceivable demand within the following 60 days.

The United States Government could easily be prepared to deliver such machines in the desired daily quantities within 30 days by the following method:

In each selected industrial center establish a Government storage plant in which would be stored the necessary patterns, jigs and equipment to make such machines; and in which would also be kept a list of the plants in the territory equipped to make the required parts. Upon order from Washington the patterns would be shipped to the designated foundries and, beginning with the third day, castings would be received at the rate of one casting a day per pattern. It would probably require about three weeks to manufacture the various working parts of the machine, but within 30 days at the outside, completed machines would be ready to run in the munition plants. The number of machines added to the equipment daily would be the same as the number of patterns from which castings were made. This record could be bettered by stocking in the warehouse the various machine parts, aside from the large bed castings, sufficient to make up machines of a desired daily output during the period found necessary. If this were done completed machines could be delivered to the munition plants within a week of authorization by the government.

Ten such manufacturing centers could be established, as for example, Philadelphia, Cleveland, Cincinnati, Buffalo, Pittsburgh, Minneapolis, Milwaukee, Birmingham, St. Louis, and Chicago, and within 30 days each unit could be producing shell-making machines at the rate of from 10 to 40 machines

a day, depending on the size and nature of the machine being produced. Moreover, the total cost to the U. S. Government for the patterns, jigs, and equipment necessary for such a plan would be approximately but $1,000,000.

MUNITIONS DESIGN FOR QUANTITY MANUFACTURE

By J. E. OTTERSON,[1] NEW HAVEN, CONN.

This paper deals with the question of the relation of design to quantity manufacture, with particular reference to the problem arising from the undertaking of quantity manufacture under abnormal conditions, and especially by manufacturers who may not have previously manufactured the particular product in question.

The term *design* must be broadly and specifically defined, and will here be taken as including not merely the general conception of the particular product which might be termed the *inventive design*, but also the full consideration by the designer of all questions affecting the design, manufacture, and service. It is obvious that the design must lend itself to abnormal manufacturing conditions. The term *design* will, therefore, be here understood as including the determination of all the limiting conditions which will permit the product to fulfill the purpose of the design.

Quantity manufacture should not be undertaken when the design is in the experimental stage. Models and samples should first be made and thoroughly tried out to the satisfaction of the designer, the manufacturer, and the consumer. Such models should embrace the limits of tolerances and thus serve to test the judgment of the designer in establishing such tolerances.

It is essential that the designer and the manufacturer recognize in full their respective responsibilities. The designer is responsible for the proper functioning of the completed product, provided it fulfills the specifications set forth in the design. The manufacturer is responsible for fulfilling the specifications set forth in the design.

The designer should make his design and specifications so clear, precise, and complete as to preclude any possibility of subsequent misunderstandings as to the exact intention of the design and as to the responsibility for any failure to function.

Standards of design should be absolute and not relative, expressed in terms of standard units of measurements and not in terms of relative exactness involving personal opinion and judgment as to the relations existing.

Designs for quantity manufacture usually prescribe some requirements as to interchangeability, and presuppose a system that is commonly called *interchangeable manufacture*. The term *interchangeable*, as frequently used, is indefinite and relative, and should not be used by the designer as a save-all to care for omissions from the specifications or as a substitute for the exact and absolute expression of the requirements of the design in terms of standard units of measurements. The term *interchangeable* has some significance as evidence of broad intent and general purpose, but is so lacking in exactness as to form no satisfactory basis for contractual or other obligations. It is, therefore, a dangerous term and should be used only in a supplementary sense.

Interchangeability increases in difficulty of attainment in ratio to the complicity of the product, the volume of manufacturing, the continuous operation of equipment, the abnormal and rush conditions in manufacturing accompanying national emergencies, the employment of unskilled and untrained labor and of labor having natural qualifications lower than those desirable for the work in hand. We must recognize that cutting tools lose their edges and exact form through wear, that machines do not continually remain in exact alignment and adjustment, that materials do not run absolutely uniform, and that the human element is a variable one. By reason of a combination of adverse conditions, absolute interchangeability may be impossible of attainment.

The designer must recognize, therefore, that peace-time standards of exactness cannot be maintained under war conditions, and that the standards of a factory that has been making a given article over such long and continued periods of time as to permit of the tuning of material and the training of personnel to exact repetitive performances, cannot be applied to the factory that must expand its facilities manyfold over night and deal with untried equipment, processes, and personnel.

In peace time the designer may quite properly seek to establish standards with such restricted tolerances as to enforce a high engineering standard, in order to preclude all possibility of failure of his design, and insure the success of his own work by placing a greater burden of accomplishment upon the manufacturer; but where the problem is one of production for war, the interest of the individuals must give way to the common good, and they must recognize a common purpose free of all antagonism and give each other all the tolerance that is possible, with the provision of a satisfactorily functioning product under urgent adverse conditions.

The problem before the designer of products for quantity manufacture under such conditions is, therefore, to give the manufacturer as *wide latitude* as possible without embarrassing the functioning of the product, and the suitability of the design to quantity manufacture under war conditions may properly be measured by the extent to which it meets this requirement.

It is recognized that this places upon the designer a decidedly heavier burden than is ordinarily assumed by him, but it is necessary that this should be the case if the design is to lend itself to the most rapid manufacture under the adverse conditions presumed.

This can best be accomplished by establishing as an essential part of the design a definite system of gaging, including the determination of gaging and holding points the control of which will control the functioning of the product, and prescribing tolerances at such points that are possible of attainment under the abnormal conditions of manufacturing under discussion.

It is the practice of some designers and manufacturers to prescribe exact dimensions as between two gage points and to establish no tolerances in connection therewith. The intention is that the manufacturer shall work as near to the absolute measurements as possible. Obviously this establishes no standard whatever. Since it is impossible to work to exact measurements, it places an unreasonable burden upon the manufacturer, who must assume the responsibility of prescribing the tolerances and instructing his help, permitting them to prescribe the tolerances according to their own judgment—obviously a loose method of operation. Every gage point should, therefore, have the tolerances clearly defined by the designer and these tolerances should be acceptable to the manufacturer, and, once accepted, should be adhered to. To

[1] Winchester Repeating Arms Co.

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prescribe tolerances less than required for proper functioning is uneconomical, since it demands unnecessarily exact operation and enforces extreme inspection practice, with consequent unnecessary rejections and reworkings.

Absolute requirements or measurements are justifiable only as applied to unimportant points or parts, where it may be safe to leave the question of tolerances to the judgment of the operator or of the inspector. In other words, we apply absolute measurements to those points about which we are not particular; where exactness is required tolerances should in all cases be provided in connection with the design.

In addition to providing a workable system of gaging, the designer must give consideration to materials and processes of manufacture. The materials prescribed by him must be such as to be readily obtainable in the broadest possible market under the abnormal conditions existing. It is important that the specifications for materials provide as great latitude as practicable, and that no restrictive requirements be included which will unnecessarily prevent the use of commercial material. In addition, the materials prescribed must not present any serious difficulties of working nor place an unnecessary limit upon cutting speeds, nor unnecessarily increase the consumption of cutting tools.

The responsibilities of the designer and the manufacturer are further defined by consideration of the problem of inspection. Inspection should be of two kinds and for two purposes:

a *Process Inspection*—the inspection of the work in process to determine the satisfactory performance of the operations; and

b *Product Inspection*—the inspection of the completed product to determine its satisfactory functioning qualities and its acceptability for the purpose for which it was designed.

The process inspection is obviously the responsibility of the manufacturer, and is his assurance that his manufacturing facilities are performing according to the standards set, his guide for the correction of manufacturing abuses or shortcomings, and his protection against the rejection of the completed product.

The product inspection is obviously the responsibility of the organization that is going to use the product, and is at once an inspection of the design and of the manufacture.

If, in connection with the product inspection, the product should be found not to function properly and yet pass a satisfactory process inspection—that is, come within the tolerances laid down by the designer—the responsibility is obviously with the designer, and the adjustment must be between him and the consumer of the product.

PROCURING MATERIALS FOR MUNITIONS

By C. B. NOLTE,[1] CHICAGO, ILL.

After the first two months of the present war General French, of the English Army, said: "The problem set is a comparatively simple one—munitions—more munitions—always more munitions." The General's statement is undoubtedly true to a large extent at least, as it has been brought home to us that munitions certainly do constitute a most important problem in a war of any magnitude; but there are probably many manufacturers in this country today who will not exactly agree as to the simplicity of the problem.

The United States is exceptionally fortunate, however, in the possession of extensive and valuable deposits of the principal metals and materials for explosives required for manufacturing munitions. Of the world's supply, this country normally produces approximately 40 per cent of the coal and iron, 60 per cent of the copper, 65 per cent of the petroleum, 32 per cent of the zinc, and 33 per cent of the lead. It is apparent, therefore, that our domestic supply of the most important raw materials is ample for the manufacture of artillery ammunition, guns, cartridges, and vehicles which probably constitute the class of munitions that is required in the greatest quantity.

The United States Government arsenals are entirely inadequate, in time of war, to supply the needed products for war use, and this duty will fall, to a large extent, upon private industries. The amount of munitions that has been supplied during the war is no criterion of the amount that can be produced in this country. Many concerns that have participated in this new industry built entirely new plants for that purpose in order not to interfere with their increasing domestic trade. In addition to innumerable smaller manufacturers, there are over 35,000 manufacturing and equipment concerns in this country, each doing an annual business of over $100,000. Almost every industrial plant has operating equipment suitable for producing some munition part.

The manufacture of shrapnel and other shells does not require special machinery, and car-building and car-material plants, motor-car factories, and forge and machine shops are equipped to participate in this work. Watchmaking, typewriter, printing-machinery, office-equipment, scientific-apparatus, and electrical factories, as well as many other small machine shops, have been readily adapted to the manufacture of shrapnel and high-explosive fuses. The majority of machinery and locomotive manufacturers have machined shells. In addition, car and locomotive builders can construct field kitchens, ammunition wagons, gun carriages, and conveyances. Optical and jewelry factories are producing sights, aiming devices, and periscopes.

It requires more special machinery to produce small arms and small cartridges satisfactorily, but even interesting and surprising resourcefulness has been exhibited in the manufacture of these in ordinary plants.

Only powder manufacturers, however, are able to make the necessary explosives. The most important materials used in explosives today are obtained from coal tar, a by-product of coke ovens. Coal tar and its derivatives are produced principally by the various steel companies, and whereas there was but one concern recovering benzol and toluol before the war began, nineteen concerns had constructed new plants for this purpose by the end of 1915.

The motor truck has proven to be an extremely necessary part of army equipment; but by means of new jigs and fixtures, the many pleasure-car factories, with their ever-increasing outputs, are readily converted into motor-truck factories. Aeroplanes, most important for fire-directing, are now being made upon a commercial basis in this country by over twelve firms. In addition, there are over forty factories producing a small number of machines of some special or experimental type which can be standardized in wartime. On account of the short actual flying life of the aeroplane, however, it will

[1] With Robert W. Hunt and Co.

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be necessary to adopt extreme measures to bring the production to a satisfactory figure.

Since, strictly speaking, munitions include all supplies and equipment necessary in war, with the exception of men and money, only the characteristics of the more important materials can be considered within the limits of this paper.

The gun proper of the usual field gun is subjected to a suddenly applied pressure of from about 35,000 to 40,000 lb. per sq. in. and is generally made of nickel steel of over 90,000 lb. per sq. in. tensile strength, 60,000 lb. per sq. in. elastic limit, and an elongation in 2 in. of 18 per cent. Rigid inspection and tests of this material are necessary before it is worked. The artillery wheels, springs, hollow axles, and recoil cylinders of field guns are made of ordinary materials used at automobile-wheel factories and forge plants.

The two principal types of projectiles are the shrapnel and high-explosive shell. The shrapnel body is not intended to break or explode when subjected to an internal pressure of about 20,000 lb. (the force exerted when the charge leaves the shrapnel), and is made of steel with a yield point of from 80,000 to 100,000 lb. per sq. in. Further, American shrapnel must, when finally treated, give a tensile strength of, in some types, 110,000 and others 120,000 lb. per sq. in., with an elastic limit of 80,000 lb. and 90,000 lb. per sq. in., elongation in 2 in. of 15 and 16 per cent, and reduction in area of 40 and 45 per cent, respectively. Steel for this purpose is furnished by the steel mills, and contains carbon from about 0.35 per cent to 0.45 per cent, manganese 0.50 to 0.80 per cent, phosphorus and sulphur not over 0.04 per cent each, chromium 0.70 to 1.20 per cent, vanadium 0.12 to 0.24 per cent.

Shrapnel steel, as produced by the large steel mills in this country, is furnished in three different forms: rough-turned bars, forgings, and rolled-steel rounds. The latter form has been used with considerable success and exceedingly rapid production.

The ordinary shrapnel fuse is made of several brass parts, the material for which can be produced by modern brass foundries. The usual composition of this material is about 59 to 61 per cent copper, 37 to 39 per cent zinc, and about 2 per cent lead, resulting in a tensile strength of about 45,000 lb. per sq. in., elastic limit of 27,000 lb. per sq. in., and 30 per cent elongation in 2 in. The fuse bodies and caps are generally forged, whereas the timing rings and other parts can be cut from brass tubes. The brass cartridge cases which hold the propelling charge for the shrapnel are drawn from brass disks cut from bars rolled by the various brass rolling mills. There is nothing unusual in the specifications for cartridge-case material, copper varying from 66 to 73 per cent, according to different purchasers' specifications, with zinc from 27 to 34 per cent, and with a tensile strength from 43,000 lb. to 54,000 lb. per sq. in. and an elongation of from 28 to 32 per cent in 2 in. The usual specification allows a range of 3 per cent in the copper and zinc contents; for example, 69 to 72 per cent copper and 28 to 31 per cent zinc.

The high-explosive shell is made of steel and is intended to break into a large number of pieces upon impact and explosion. It is unusually forged from steel rounds, billets, and cast ingots, with carbon from 0.40 to 0.55 per cent, manganese 0.40 per cent, to 1.00 per cent, phosphorus and sulphur not over 0.04 on 0.06 per cent each, and silicon from 0.18 to 0.30 per cent. Some of the steel for this purpose also contains nickel not to exceed 0.50 per cent and copper not over 0.10 per cent.

This grade of steel is easily produced by practically all of the large and small steel mills in this country, and, in fact, has been produced already in considerable quantities for such purposes. The fuse for the high-explosive shell does not present the same difficulties as that of shrapnel and is usually made of ordinary steel and copper alloys.

The first problem in the procuring of shrapnel, high-explosive shells, fuses and cartridge cases, is the delivery of suitable raw material. Care must be taken, therefore, to secure steel and brass of the proper chemical composition and physical characteristics. In addition to a careful study and understanding of the specifications and drawings, one of the most effective and economical means of obtaining the desired material rapidly and without excessive loss has been found to be by inspection of the material at the rolling mills before it is shipped to the finishing plants, by an experienced and trained organization.

Regarding explosives, the majority of commercial explosives are not suited for use in shells on account of their inability to withstand, without explosion, the shock of firing from the gun. Smokeless powder is produced by special plants which treat cotton fiber with such materials as nitric and sulphuric acid, alcohol, and ether. Nitrogen, used in the manufacture of nitric acid, is chiefly derived from the sodium nitrate found in Chile, but European nations are now obtaining a large amount of nitrogen from the air by the fixation process. Pyrites for making sulphuric acid is found in this country, although much of the best is imported from Spain. The United States manufactures ether and alcohol in abundant quantities. Glycerine, a by-product of soap manufacture, is produced in large amount at home. Cordite, the explosive which has come into such great favor because of its combination of propellant and high explosive qualities, is obtained by further treatment of gun cotton and nitro-glycerine with acetone, which is a product of wood distillation and which is also obtained from a special fermentation of starch. Trinitrotoluol is obtained by nitration of toluene, which constitutes about 36 per cent of crude benzol, a by-product of coke ovens.

Trinitrotoluol possesses an explosive force of about 119,000 lb. per sq. in., while the explosive force of picric acid is about 135,000 lb. per sq. in. Owing, however, to its propellant qualities and the fact that it does not form dangerous salts by combination with iron and other metals in contact, trinitrotoluol is superior to picric acid as a war explosive. Picric acid does yet, however, play an important part in priming compositions and propellant powders. It, too, is obtained from coal-tar derivations.

Although, as has been outlined, the United States is well equipped to furnish the principal materials for munitions, it is apparent that there are many other phases of the problem which it has not been possible to consider here. If the requisites of war are to be successfully met, every industrial worker, whether he be engaged on the farm, in the mine, or in the factory, has an important task to perform; every manufacturing plant has a definite obligation; and all the resources of our country must be systematically brought to their utmost utility.

LIMITS AND TOLERANCES FOR THE MANUFACTURE OF MUNITIONS

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THE purpose of this paper is to direct attention to some of the practical aspects of the question of limits and tolerances, as customarily applied to the manufacture of

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munitions, rather than to attempt to establish standards of high technical value in assigning definite limits to the several classes of dimensions involved.

Most mechanical men who have had recent experience with munitions manufacture will agree with the statement that their troubles have not to any great extent been due to inherent difficulties with the tolerances in general; but have principally been caused by such factors as incomplete or inconsistent drawings and specifications, and lack of mechanical judgment on the part of inspectors in interpreting the drawings and specifications and in the use of limit gages. In fact, these aspects of the subject are of such major importance that it would seem that technical refinements may be postponed until standards of practice have been established with respect to these factors.

The average munitions drawing is fairly open to criticism and leaves much to be desired in the way of clearness and consistency. Such defects as the following are often encountered:

a Flat dimensions without any tolerances
b Dimensions with one tolerance only, either plus or minus
c Overlapping tolerances on two parts which assemble together
d The sum of the tolerances on intermediate dimensions are not in agreement with the tolerances on the overall dimension
e No limits are specified as to permissible eccentricity between concentric cylindrical surfaces, or between two parts which assemble together
f In the case of screw threads on two parts which assemble together, but where interchangeability is not required, no specifications are given as to the nature of the fit.

Defects *a* and *b* can be readily remedied by establishing an invariable rule that all dimensions must be the mean dimensions with equal plus and minus tolerances.

Defect *c* usually occurs in the tolerances for external and internal threads on two parts which assemble together, and is occasioned by losing sight of the fact that the maximum external thread must be slightly smaller in diameter than the minimum internal thread, in order that these extremes may assemble properly.

Defect *d* can best be avoided by establishing the invariable rule that all dimensions in the same direction must start from a common reference line.

Defect *e* is a fruitful source of trouble to the munitions maker, and consequently in all cases where close concentricity of cylindrical surfaces is essential, definite limits of eccentricity should be specified on the drawings.

Defect *f* can conveniently be illustrated by considering the fit of a nose-piece or base-plug external thread, in the internal thread in a shell. In this case the nose piece or base plug virtually becomes an integral part of the shell after it has been assembled. In fact, it is common practice to finish-machine or grind these parts after they have been assembled, and in subsequent operations such as loading keep them together by similar markings. Manifestly, all that is required from the standpoint of utility is that the nose piece or base plug should screw into the shell easily, but without too much looseness. As such threads are usually quite coarse, liberal tolerances are in order, but the dimensions and tolerances must be properly assigned in order to avoid the possibility of too much looseness. This can readily be accomplished by letting them overlap to some extent, which will of course result in producing some nose pieces and base plugs which will be too large to enter shells having minimum threads. This apparent difficulty is overcome by grading the nose pieces and base plugs, as, for instance, small, mean, and large. A mark can also be put on a shell at the time it is gaged which will indicate to the assembler which grade of nose piece and base plug to use.

RELATION OF TOLERANCES TO WEIGHT

Perhaps the most striking defect, in shell drawings particularly, is the discrepancy between the tolerance specified for the weight of the shell and the variations in weight of the shell from making one to maximum external and minimum internal dimensions, and another to minimum external and maximum internal dimensions. As a rule, shell drawings and specifications allow a variation in weight of plus and minus one per cent of the mean weight for the smaller sizes and less for the larger sizes, whereas the extreme dimension tolerances would permit two or three times as much variation in weight. Furthermore, no dependence can be placed on the assumption that a shell machined to the mean dimensions will have the mean weight specified on the drawing. Whether or not these discrepancies are intentional or accidental the writer is not informed, but it seems obvious that the drawings should be revised.

From the standpoint of ballistics uniformity in weight of shell is highly desirable, and consequently close weight tolerances are to be expected; but the drawings and specifications should sound a clear note of warning so as to prevent a manufacturer from proceeding on the assumption that the dimension tolerances can be used indiscriminately. Some tolerances bear evidence of having been added—probably to meet some difficulty in manufacture—without perhaps due consideration being given as to the extent to which the weight would be affected. In any event, it seems imperative that the drawings should be revised so that shells machined to the mean dimensions, and of steel of the specified quality, will have the mean weight.

If ballistic considerations permit, the weight tolerances should be increased, since they are at present the limiting factor. The drawings plainly state that advantage cannot be taken of all the extreme tolerances on any one shell.

These considerations are not advanced as an argument against larger dimension tolerances than weight tolerances, since liberal dimension tolerances afford a maximum of munitions production; but rather to caution the manufacturer to consider carefully all possible combinations of the tolerances which will produce the greatest uniformity in weight of the finished product, and also to suggest to the ordnance engineer the desirability of plainly pointing the way to attain the desired results.

THREAD TOLERANCES

Perhaps the most difficult operation in munitions manufacture is the cutting of internal and external threads within close limits. The Whitworth form of thread is particularly difficult to cut and has been the cause of endless trouble in recent munitions work. We all regard the rounding of the top and bottom of this thread as particularly iniquitous and we are apt to regard the United States form of thread as greatly superior. As a matter of experience, it is quite difficult to maintain the size of the United States form of thread within close limits. The requirement that this form of thread shall fit on the top and bottom, as well as on the all-important angle, is the chief source of trouble. The very existence of this requirement results in most of the fitting occurring at the

top and bottom of the thread, rather than on the angle. It is practically impossible to avoid this condition since the tops of the threads on a tap wear away very quickly and therefore the tap does not continue to cut internal threads of full depth. As the thread gages are made of standard form, it is obvious that much of the work will not pass the gages, although perfectly correct as to angle diameter and pitch. To a less degree is the same condition true of dies and external threads. This defect is universally recognized in American machine shops and is quite commonly overcome by making the diameter of taps slightly larger than standard, so that they will cut an internal thread deeper than standard and also cut a larger hole or core than standard. This affords a clearance at the top and bottom for the external thread. It seems manifest that this necessary and customary practice should receive official sanction in the drawings and specifications for munitions, and that limits for these clearances should be specified.

INDIVIDUAL JUDGMENT OF INSPECTORS

Next in importance as affecting the manufacture of munitions is the question of mechanical judgment in interpreting the drawings and specifications on the part of the inspectors, and also in regard to the proper use of limit gages. Although many inspectors are men of excellent mechanical judgment and experience, a large number of necessity have not these qualifications. In fact, it would be detrimental to other lines of manufacture to require that only experienced mechanics be selected as munitions inspectors. It therefore seems that the obvious solution of this difficulty is to make the drawings and specifications so clear and comprehensive that men with little mechanical experience can become efficient inspectors. The specifications should clearly specify such details as kind and quality of finish for all surfaces, whether by turning or grinding, and if by turning whether the tool marks must be removed by filing. Some surfaces can, in the interest of maximum production, be left semi-finish-turned, and the specifications should in such cases so state. In general, this plan can be made most effective by basing the requirement of the specifications on actual results obtainable with modern machine tools, and all unnecessary refinements should be eliminated.

Regarding the proper use of limit gages, it is perhaps difficult to lay down general rules, but certainly such a fundamental one as that gages should never be forced can be advanced without hesitation.

MACHINE-TOOL LIMITATIONS

The limits of accuracy attainable on machine tools must be taken into consideration in determining how limit gages should be used. The screw thread affords a good illustration of this point. In a part where a threaded hole goes entirely through the part, it is not very difficult to cut threads of uniform diameter in the sense that the thread is uniform throughout its length and that it does not taper. In bottom-tapping a shallow hole, however, or in cutting a short external thread, both are apt to taper slightly, or at least the first thread or two will be thin. In the first case it is perfectly proper to require that the maximum thread gage shall not enter at all; but the second case manifestly demands different treatment. A rational rule would be to allow the minimum thread gage to screw in one-third or one-half the depth of a shallow not-through hole, and the same allowance should be made in the case of a short external thread. This proposition should be judged from the standpoint of utility rather than ideality, particularly when one stops to consider that the mechanic can, by cutting the external thread in the proper direction, make these inaccuracies actually balance each other.

To sum up, maximum production, which is the principal aim of any revisions, can be most readily attained by increasing the weight tolerances in the case of shells particularly. If, however, the ordnance engineer cannot allow any greater variations in the weight of shells, then, at least, the alignment of mean weight with mean dimensions, as outlined in the foregoing comments, will, it is believed, prove to be an important step in the right direction. As regards other munitions, where weight variation is not so important, much can be accomplished by aligning the dimension tolerances with the capacity for accuracy possessed by modern high-speed machine tools.

GAGES AND SMALL TOOLS

By FRANK O. WELLS, GREENFIELD, MASS.

Member of the Society

OF first importance in the manufacture of rifles, guns and munitions of war are gages. There are many types of gages, but the one used in the manufacture of munitions is the dimension or limit gage. Whatever instrument is used must be able to measure accurately and rapidly, and must also be durable, as very slight wear will destroy the accuracy.

It has been well said that if we can measure an article we can make it. The difficulty lies not in the making, but in the measuring; and our greatest obstacle in exact measurement is the human element.

In olden times the human element was the controlling factor in all operations. Work was done in very small quantities and was not interchangeable. Some work was good and some was poor, all depending on the man who did it. To meet the demand of the present day, we must have progressive manufacturing, where each man has only a small part of the work, and that part must be done by an ordinary workman. All this calls for a method of measurement different from that formerly used. Then we wanted one piece, now we want thousands of pieces, all alike and each one an exact duplicate of the other. This is easily accomplished by our printed instructions and gages, and with these we can start a large number of factories making war materials that will be one hundred per cent good, and also standardize the cost of production.

Improperly designed gages cause poor work and a lack of interchangeability, making the cost of production and the cost of assembling greater. Our Government should take advantage of the knowledge of this fact, obtained at such great cost in the present war, and should standardize all its operations, gages, and measuring tools, so as to avoid a repetition of mistakes of this kind.

The Government should have, first of all, its blueprints prepared indicating the proper tolerances perfected by tests and careful practice. The sequence of operations and the time taken to do the work should also be perfected and put in printed form with the necessary illustrations showing the set-up, as well as the best way to handle the work, both in the operation and gaging. This would enable all factories to standardize their productions.

The importance of the best methods of measuring is illustrated in a report from the U. S. Ordnance Department, in

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which the statement is made that the cost of inspection is from 10 to 12 per cent of the total cost of manufacturing. These are startling figures, and indicate that the proper gaging methods had not been used.

The output of the U. S. Government arsenals for the year 1915 was $11,284,113.95; for the year 1916, $9,471,300. It has been estimated on good authority that this could have been increased at least 50 per cent without increasing the size of the plants, by having a larger supply of gages and tools. The cost of such tools and gages is estimated at 20 per cent of the total cost of the plant, which shows conclusively the need of gages and small tools.

Few people realize that our Springfield rifle has more than one hundred parts and requires 1400 distinct factory operations. To produce 1,000,000 rifles requires $360,000 worth of gages for the original equipment, while renewals cost $400,000, making a total of $760,000. Each 1000 rifles made require 4800 gages. The renewal of the gages costs about 50 cents per gun. To make 10,000,000 rifles in 200 days requires at least sixty more arsenals than we now have. The war material most talked about is ammunition, of which our Government uses about 17 sizes at present. The cost, including the upkeep of gages, used in the making of 1000 rounds of ammunition per day, with a steady production for 200 days, is at least $2,225,000. These figures have been carefully worked out by makers well versed in the manufacture of gages for ammunition. It has been estimated by good authority that we should be able to make at least 200,000 rounds per day. The vast importance of the whole gage question can be realized.

Of course, some sizes of ammunition have to be made in much larger quantities than others. Careful estimates show the special jigs and fixtures would cost nearly double what the gages would. So far, the paper has only touched on ammunitions and rifles. To have everything on hand necessary, the figures given have to be multiplied many times.

There are today some 3,500,000 people in Great Britain engaged in making munitions of war in over 4500 factories. In doing this work to advantage, each workman should at least have $25 worth of gages, tools and fixtures.

The majority of contracts taken for ammunition in this country were taken by manufacturing organizations without experience on war material, and the gages first designed were not the best possible to insure economical assembling of the parts, with the result that a great many rejections were inevitable during the first months after production was attempted.

Our Government should provide itself with all the gages, tools, jigs, and fixtures far in advance of any possible expectation of requirement; the cost is small compared with the results obtained. This is a very simple business proposition—what every efficient manufacturing company would do.

It is a very poor policy to cut down on the number of gages and small tools. It is far better to use every labor-saving device possible. All this means a saving in high-priced labor, and this is very important in time of need when we cannot get the necessary skilled labor.

It is considered the best practice in manufacturing to put the thought and money not so much in the large machinery as in the small tools. The most important of all are the gages, and these must be so designed as not to have any guesswork about it. We must know that every part is machined right. We must be able to say, "We know this is right," and not say, "I guess we are right."

To most people gages seem of small importance, but as this paper endeavors to show, they are quite the reverse.

IMPORTANCE OF INTELLIGENT INSPECTION IN MUNITIONS MANUFACTURE

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Member of the Society

A STRIKING example of the difficulties that may arise in inspection work has been afforded during the present war in one contract for the manufacture of 5,000,000 rounds of ammunition which was completed by the contractor subletting the work among more than one hundred manufacturing plants in the United States and Canada, the time and the magnitude of the work making this necessary. The contractor, for his own protection, had to inspect all the product as it was made by the sub-contractors, and a corps of inspectors was required in each plant, the number of such corps being equal to the number of plants doing work. Great difficulty was experienced in getting men qualified to do this work, because there were practically none in this country who had experience in the manufacture of munitions, and but few available who had any kind of inspection experience.

To expedite the delivery of the finished product, the Russian Government placed its inspectors in the plants of the sub-contractors where they received the finished parts directly from the contractors' inspectors. Russia was as little prepared to provide the required number of qualified inspectors as was the contractor, and in consequence the manufacturer had inflicted upon him so-called inspectors selected from every walk in life, it seemed, except the mechanical, and barbers, bartenders, butchers, students and teachers were the usual thing and the practical man the exception.

The specifications for the ammunition were so drawn as to leave a great deal to be interpreted by the inspector, who was rarely qualified to intelligently pass upon the point at issue. The following extracts, copied from the specifications, will serve as examples:

> "There shall be no scratches, slivers or cuts on these parts."
>
> "If, independently of the above, in order to ascertain the qualities . . . the Receiver shall deem it necessary to make . . . other experiments, the factory shall give him all necessary means for making such tests."
>
> "For the measuring and verification of the projectiles the factory is under obligation to furnish a sufficiently vast, light, dry and warm room and place at full disposition of the Receiver, as well as furnish cupboards for the keeping of verifying instruments, scales of sufficient sensitiveness, electric lights of sufficient energy, for the examination of projectiles and gross power."
>
> "For the measuring of the projectiles, the factory shall furnish the Receiver, for his exclusive use all verifying working instruments . . . prepared according to the instructions, *as well as according to the indications of the Artillery Receiver.*"
>
> " . . . the finish of these surfaces must be brought to such a degree as is obtainable when working with a tool."

The slightest scratch or tool mark was soon magnified into a cause for rejection. One sub-contractor claimed that he was required to unbox several thousand shrapnel because the Rus-

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sian inspector found a flyspeck on the copper band of one of them! In spite of the fact that gages were called for by the instructions for certain gaging points, the inspectors were not satisfied with them, but asked to be furnished with others of a design that would be more searching and exacting. Under the clause governing the finish of the shell, the inspectors were soon demanding a finish that could only be obtained by buffing, and the unfortunate part was that the manufacturers had no redress, because there were no standards of finish established; there was no set of standard gages, nor was there anyone in authority to whom the contractor could appeal and whose decision was final.

Fresh from the experience of two years' struggle to produce work under such conditions, the writer is constrained to appeal for coöperation in the endeavor to standardize and systematize the production of munitions, so that manufacturers will in future have definite instructions and standards to work to and, in the case of honest differences of opinions, a Bureau of Appeal, where questions will be decided definitely and authoritatively.

Drawings should be checked and re-checked until the possibility of error has been reduced to a minimum. Tolerances should be decided upon that will allow the greatest leeway compatible with good work.

Every effort should be made to make the specifications simple, clear, explicit and absolute. They should leave nothing open to the discretion of the inspectors. The specifications should describe the gages to be used and how to use them.

The gages used should be as few as will check up the product in all of the important features. What these gaging points and their limits should be, should be determined by competent military engineers, working with the idea of getting a product that will meet all requirements and still be practicable, so that the quality produced will not be curtailed by unnecessary refinements. Exactness should be required where it is necessary, and where it is not necessary there should be no holding down to ridiculously close limits.

Corps of inspectors should be enlisted from our numerous manufacturing plants and thoroughly drilled in the use of gages and the meaning and intent of the specifications, with particular stress laid upon the fact that inspection should be made with the idea of accepting as many as possible, rather than a high count of rejections.

Each manufacturer should be supplied with a set of correct sample gages, with their masters and grand master, by which the working gages should be made and checked.

An approved sample of the product to be made should be furnished to each factory, to be used for comparing the same with the regular product when necessary. These samples should be official, and product equal to sample should be accepted without question.

It is most important to have a bureau composed of qualified engineers to interpret specifications and render final decisions on all points that may arise. Manufacturers should have the right of appeal to this board and its unbiased opinion. At this bureau should be kept on view officially accepted samples of all parts in the various stages of manufacture, to be referred to when making decisions.

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The Academie des Sciences, according to the *Génie Civil*, has resolved to establish a national physical and mechanical laboratory for the purpose of scientific research directed toward industrial uses. The laboratory will be controlled by a council, of which half the members will be nominated by the Academy, one-fourth by the State Department, and the remainder by the chief industrial associations. The executive control will be in the hands of a small technical committee. Existing laboratories engaged in similar work will be affiliated to the National Laboratory, and will work in close relationship to the latter. Substantial funds will have to be provided for the working expenses of the laboratory and for the assistance of the affiliated institutions.

Stellite vs. High-Speed Steel. According to an account given in *Métaux et Alliages,* the hard non-ferrous alloy, stellite, invented three or four years ago in the United States by Elwood Haynes, marks a still greater advance in the art of cutting metals than established by the notable results obtained with the introduction of high-speed steel some years earlier. Where rate of production is a critical matter, as in the manufacture of ammunition, it has already made a remarkable record in competition with high-speed steel, a material which in point of capacity of production outclassed steels previously used. One of the advantages of stellite is that its hardness, which it maintains even at a red heat, is solely dependent upon the composition of the alloy, tungsten and chromium with additions of cobalt and molybdenum, and not upon the difficult and uncertain operations of heat treatment. Its fundamental advantage, however, lies in its ability to withstand a marked increase in speeds and feeds over those previously used with high-speed steels.

Among the already numerous machine shops employing stellite, the Fonderie des Gobelins in Paris reports that a daily production with high-speed steel of 120 shells of 155 mm. was increased to 200 by the use of stellite. With high-speed steel 21 minutes were consumed in roughing out at a speed of 17 meters and a feed of 0.7 mm. For finishing, the same speed and feed were employed and the same time was consumed. With stellite the roughing-out occupied 11 minutes at a speed of 25 meters and a feed of 0.85 mm. For finishing a speed of 37 meters was maintained with a feed of 1.67 mm. consuming 4 minutes. For completely finishing 1,000 shells of 155 mm., the cost of stellite is about 0.30 francs per shell. Other firms report equally favorable results in this class of work.

MACHINE SHOP PAPERS

SPECIAL emphasis has been placed on the Machine Shop Session of the Spring Meeting for the reasons that Cincinnati is the machine-tool center of the country and that the National Machine Tool Builders' Association will be in convention at Cincinnati at the time of the opening of our own meeting. Three papers are to be presented and discussed at this session, which is under the auspices of the Society's Sub-Committee on Machine-Shop Practice.

A FOUNDATION FOR MACHINE-TOOL DESIGN AND CONSTRUCTION

By A. L. DE LEEUW, PLAINFIELD, N. J.

Member of the Society

THE rapidity of progress of the various branches of engineering may be said to be in proportion to the ease with which their principles can be reduced to mathematics. This was never so clearly shown as in the case of the development of alternating-current apparatus. It may almost be said that the branch of alternating-current engineering was, like Pallas Athene, born full-grown. Here was a case where the science, the mathematics of this branch, was at hand, waiting for somebody to apply them. As a result, alternating-current apparatus has known no period of experimentation, of stumbling, fumbling progress.

Compare this with the slow, hesitating development of the steam engine in its first stages. In that case nothing was known except that steam would exert pressure; but no knowledge existed of the properties of steam, of thermodynamics, nor of the mathematics of engineering materials. The moment that the fundamental facts of thermodynamics were understood and were reduced to mathematics, the progress of the steam engine became more rapid.

It then became possible to imagine an ideal steam engine, which is another term for a 100-per-cent-efficient steam engine, and to show what is the maximum obtainable efficiency in any steam engine. It was therefore possible to express the efficiency of existing or of contemplated steam engines in percentage of the ideal engine. In other words, the ideal steam engine became the standard or unit of measurement. It was no longer possible for any designer or builder to think that he had produced a steam engine of the highest possible efficiency, merely because his steam engine was twice as efficient as some other existing engine.

SCIENTIFIC DEVELOPMENT OF MACHINE TOOLS

What are the things we should know about tools and machine tools to enable us to make these important servants of our present-day civilization follow the line of development which the steam engine has enjoyed?

Is it possible to develop a theory of the ideal machine tool, such as has been developed for the steam engine?

Fig. 1 shows two stress diagrams of cold-rolled steel, of which one specimen had a tensile strength of 95,000 lb. and an elongation in 4 in. of 12 per cent, and the other a tensile strength of 85,900 lb. and an elongation in 4 in. of 7.4 per cent. The area of both pieces was $\frac{1}{2}$ sq. in. and the length between gripping jaws 2 in. The amount of work done in separating the first piece was 3500 ft-lb. per sq. in. of section, and for the second piece 2000 ft-lb. per sq. in.

In parting the pieces, the same result was obtained as if half the piece were removed by means of a cutting tool. Of course, this way of removing metal does not permit of controlling the shape or the finish of the remaining piece; but just the same, a certain amount of metal has been removed as effectively as if it had been done with a cutting tool. If this amount of metal had been removed by a cutting tool used in one of the present-day machine tools, the amount of power required to do this work would have depended on the quality of the tool and the nature of the machine; but in no case would it have been less than $\frac{1}{2}$ hp., assuming a reasonable time element.

If the only function of a machine tool were the removal of metal, we would find that our best machine tool has an efficiency

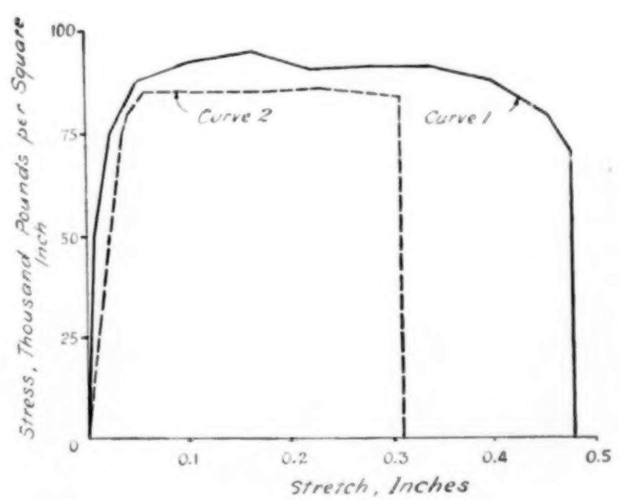

Fig. 1 Stress Diagrams of Cold-Rolled Steel

of from 0.12 to 0.22. Even the better of these figures is very low compared with the efficiency of other machines.

If chips could be removed from a piece of work by a straight pull, the ideal machine tool would be one which would remove material with the same amount of power expenditure as that required by the testing machine. While we would not expect to obtain such efficiency in practice, we would certainly aim to reach a much higher efficiency than we are able to obtain now. However, the question is whether material *is* removed by a straight pull, and this leads to the confession that the writer does not know what the exact nature of the cutting of metal is, and he believes further that he is not alone in his ignorance.

To the writer's knowledge, no experiments have been made which establish the true nature of the cutting of metals with a reasonable certainty. In The Art of Cutting Metals and elsewhere diagrams are shown of the supposed action of a cutting tool. (See Fig. 2.) The writer believes that these diagrams represent a very good first guess; but he wishes to point out that this guess is not based on anything better than the inward vision of the authors of these various works. If this guess is

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correct, then the act of cutting metal is a removal of the chip by tension, and the amount of power consumed for cutting should not be more than that required by the testing machine. If this is so, the total wastage of power in all the machine shops of the world is enormous; and it certainly would be worth while to investigate this matter thoroughly, merely from the standpoint of the conservation of energy.

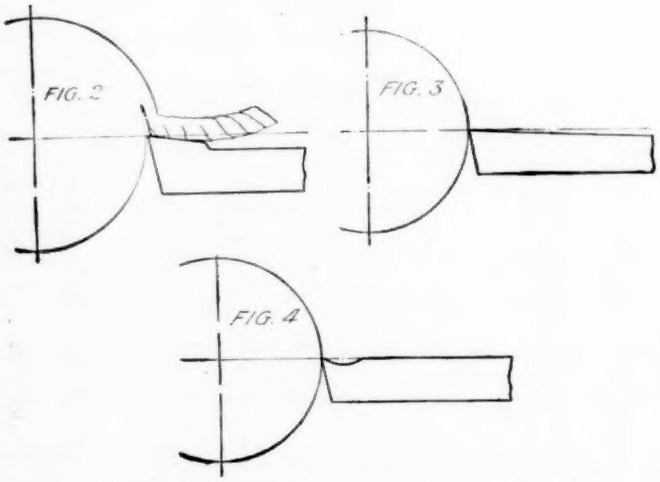
QUESTIONS WHICH NEED TO BE ANSWERED

Among the questions which should be answered before we can design machine tools in a thoroughly scientific manner are the following:

1 When we turn up a narrow disk by means of a square-nosed turning tool of which the width is greater than the width of the disk, is the action of removing the chip purely a matter of tension; or, if not, what is it?

2 Does the front end of the tool have any function at all?

3 How far from the edge of the tool is the point where the chip strikes the tool?



FIGS. 2, 3 AND 4 CUTTING WITH LATHE TOOLS

4 If the action is purely a matter of pull, and the chip does not strike the top of the tool at the cutting point, but some distance farther back, then is it necessary that the cutting edge of the tool be sharp?

5 What is the nature of the lamination of the chip?

6 How much power is required for the actual removal of the chip, for the friction between chip and tool, and how much for laminating the chip?

7 What would be the best shape for such a turning tool for this particular turning operation?

8 How does the amount of power vary with the various angles of the tool?

9 If the turning operation is not as simple as the one assumed in Question 1; if, for instance, there is a side feed, such as in ordinary shaft-turning operations, how is the cutting action modified by this side feed?

10 If the chip is removed by the action of the top of the tool, that is, if the front of the tool has no function, then what determines the nature of the finish of a cut.

11 In what relation does the power required for the side feed stand to the power required for the actual removal of the chip.

A great many other questions which could be asked cannot be answered at the present time, and still more questions would naturally present themselves as soon as we had some little elementary knowledge on this subject.

ACTION OF A CUTTING LUBRICANT

As dark a subject as the action of the tool itself is the action of a cutting lubricant. It is a well-known fact that the use of a lubricant and the nature of the lubricant used affect both the finish and the size. A very pertinent question which might be asked, is this: If the chip is laminated by tension, that is, if the point where the chip begins to separate from the work is some distance ahead of the point of the cutting tool, how can the cutting lubricant affect either size or nature of finish?

Another equally puzzling question is: If one of the functions of the cutting lubricant is to reduce the friction between chip and tool, why should we not use a heavy lubricating oil instead of a light lard oil, which has practically no lubricating qualities?

Or again, we might ask this question: If, as facts seem to show, the best results are obtained with a cutting lubricant which has little viscosity and which therefore, can readily rise between chip and work by capillary action, what is the action of the oil on the separation of the chip, seeing that the oil only gets to the point after the chip is separated?

Even more puzzling than the effect of a cutting lubricant on finish is the effect it seems to have on the size of the work. We do not see at the present time how it is possible for the lubricant to influence the size, yet that it does do this has been observed a great many times.

The writer had occasion to look into this matter when trying to determine the best cutting lubricant for automatic screw machines on small and medium-sized work. The lubricant in use was a mineral oil with 15 per cent lard oil. A certain job was selected, for which a form tool was used, and 24 screws were made with the regular compound. The screws came true to size within the limit of one-half of one thousandth. The oil was then removed from the machine and machine and tools were cleaned. The cutting compound to be investigated was substituted and another 24 screws were made. These screws were all larger than those cut with the regular oil. Furthermore, they varied from two and one-half to five thousandths over size. The machine was once more cleaned, and the original oil put back. The screws again came uniform and to size, showing that the cutting of the first 24 screws had not dulled the tool or caused any other disturbing element to enter into the equation.

The fact that the cutting compound caused the screws to be over size might possibly be explained by a difference in heating or cooling effect of the different lubricants; but how can the difference in size of screws made with the same lubricant be explained, when there was no such difference with the use of the oil?

Many other questions could be asked which can not be answered at the present time. This should not prevent us from carefully investigating the true action of cutting metals, and determining the fundamental data, if we are interested in this matter in a purely scientific way. However, the engineer should not indulge in scientific investigation, unless he feels that the results will be of practical value.

To be of value, the results should lie in the direction of saving of power, diminished wastage of tools, and less strain on the machine; or in the direction of increased output, with

or without the other advantages. That such advantages may be reached seems very clear to the author, and he wishes to outline some isolated experiments which, though not complete in themselves, point to very interesting possibilities.

Forged spindles of sixty-point carbon steel were roughed by a tool as shown in Fig. 3. As a rule, the tool was able to rough three spindles before a breakdown. In its broken-down condition the tool appeared as shown in Fig. 4. A hollow had been ground out by the chip, but a land of a little more than 1/64 in. in width had been left at the front end, showing that the extreme front of the tool had not been in action. The experiment consisted of carefully measuring the broken-down tools and making new tools of just that shape; in other words, a tool like the old tool, but with a hollow ground in the top of the same shape, size, and location as in the old tool.

This tool is shown in diagram in Fig. 4. The hollow was carefully polished, and a tool thus prepared would rough from 9 to 13 spindles. Examination showed that the hollow in the tool would remain smooth almost to the last, and that a complete breakdown followed very soon after the surface of the hollow began to show scratches. No tests of power consumption were made, but it may be expected that the power required with the old tool was more than with the new tool, as the chip did not have to bend so sharply and as the work required for hollowing out the tool was omitted.

Another interesting point about this tool was that the actual contained angle between the front of the tool and the front of the hollow was much less than we would have dared to make between the front and top of an ordinary lathe tool, especially if this lathe tool were to be used for roughing. Nevertheless, under the conditions given, this tool, with the small front angle, stood up better than the original tool with the large angle.

In The Art of Cutting Metals, Mr. Taylor stated that his experiments showed no perceptible difference in power consumption for various contained angles of the cutting tool. The writer thought that this conclusion would probably be correct only for the range of cutting angles tried by Mr. Taylor. He imagined that the relation between contained angle and power consumption would probably be a curve of the nature of Fig. 5, and that all the experiments made by Mr. Taylor were within the horizontal part of the curve.

The writer, therefore, set out to experiment with angles much below the angles mentioned in The Art of Cutting Metals. Realizing that an ordinary lathe tool would not stand up with much smaller angles than those used in present-day practice, he devised the tool shown in Fig. 6. This tool is a body of revolution, and was held in a rigid block of metal, and directly over the lathe carriage. Fig. 7 shows the arrangement of tool and tool holder used. The tool was used for turning, preparatory to grinding, milling machine overarms, about $4\frac{1}{2}$ in. in diameter and 5 ft. long. When the tool gave out, it was turned in the tool holder so as to present a new piece of the edge to the work. In this manner, from 12 to 16 settings could be made with one sharpening of the tool. The sharpening itself was a matter of circular grinding. The tool would make a very smooth cut, and without a steady rest would turn half the length of the bar with a variation in diameter of less than three thousandths. The surface of the work was unusually smooth, and the amount required for grinding was much less than usual. Unfortunately, the lathe on which this work was done was too large and heavy to make accurate power readings for so slight an amount of power consumed, the cut being only 3/16 in. reduction in diameter, and with a feed of 1/16 to 3/32 in. The action of the tool was quite peculiar, and did not give one the impression that metal was being cut. Though nothing was learned about the relative efficiency of this tool, the writer thinks it worth while to bring it to the attention of the Society, on account of the possibilities for further investigation to which it points.

This matter of the relation of the contained angle to the power consumption for a given cut had previously led to the introduction of the helical cutter, where the actual angle of

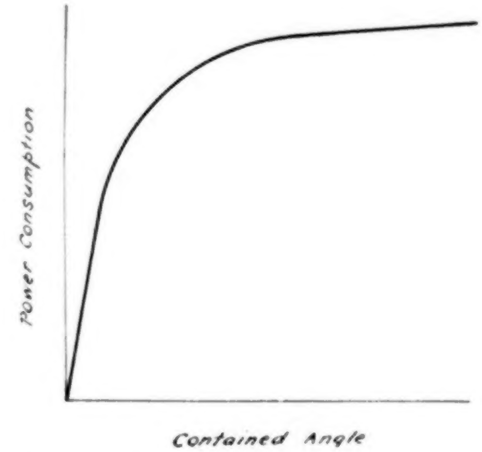
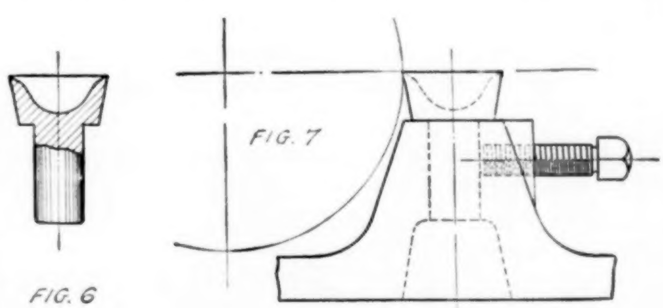


FIG. 5 PROBABLE RELATION BETWEEN CONTAINED ANGLE OF CUTTING TOOL AND POWER

the tool is not small, but where the tool is presented to the work in such a manner as to have the effect of a small angle.

Another experiment, more or less related to the same question, was an attempt to use a rotary lathe tool, such as shown in Fig. 8. The edge of this tool would bear up against the work



FIGS. 6 AND 7 AUTHORS' SMALL-ANGLE TOOL AND TOOL HOLDER

(Fig. 9) so as to have a very slight difference in speed between the work and the tool, and it was further set in such a way as to make the virtual cutting angle very small. The result was that it became possible to use very high cutting speeds without any apparent effect on the tool. The cutting speed was limited by the machine only. With a reduction of 3/16 in. in diameter and a feed of 12 to the inch, a cutting speed of 650 ft. was used for cast iron as well as for steel. All cutting was done dry. Again no attempt was made to get accurate data as to power consumption, especially as it was realized that the lathe in its present form is not well adapted to this kind of cutting tool. The chips made by this tool were not broken up, and were practically solid steel bars. Furthermore, the chips as they came off the lathe were cold enough to be caught in the hand. It is therefore very likely that a test would have shown a remarkably low power consumption.

Though the foregoing experiments are incomplete in them-

selves, they do show that there are great possibilities before us, and, further, that these possibilities lie away from the present-day shop practice. The writer believes that it would be almost useless to try experiments along a great many lines, and by a great many experimenters, without a complete plan of campaign; and that such a plan of campaign should be based on some theory, or at least on some hypothesis; and he further believes that no such hypothesis can be developed unless we start in collecting some elementary data.

A few years ago, Mr. L. P. Alford, who was then in close touch with the writer on this subject, approached Dr. Stratton of the Bureau of Standards, with the view of having that bureau take up the first investigation of the process of cutting metal. Dr. Stratton promised the assistance of the bureau, and at a preliminary meeting a general plan of campaign was discussed. The writer believes that an order was placed for a special dynamometer for measuring the stresses in various directions when planing metal. This proceeding will probably give some valuable data, but, according to his ideas, not

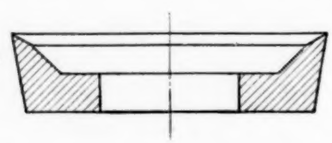


FIG. 8 EXPERIMENTAL ROTARY LATHE TOOL

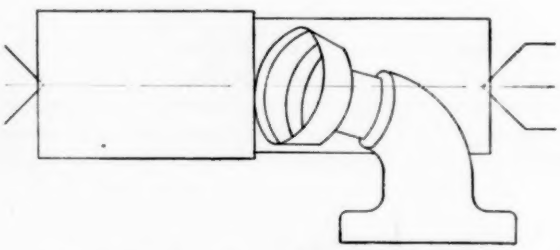


FIG. 9 ROTARY TOOL MACHINING SHOULDER

of a kind which will make it possible for other experimenters to use them as a basis for their own experiments.

SUGGESTED LINES OF EXPERIMENTATION

The writer believes that interesting results may be obtained by following a line of experimentation such as the following:

An instrument should be built, somewhat along the lines of a microtome, in which a soft material is to be cut by a razor-like blade or tool. This tool should be arranged so that it can present various angles to the work, and tools of various contained angles should be experimented with. The angles presented to the work should vary as to angle of clearance, angle of rake, and angle of shear. A dynamometer, which should be part of the instrument, should register the pull required for the cut. The material to be cut should be standardized, and it is suggested that paraffin may fill all requirements; by selecting a paraffin of standard melting point, we would also get a material of standard hardness. In this manner the relation between cutting angles and power required could be established over a very wide part of the curve. Though the actual figures obtained would not be immediately applicable to metal cutting, it would make it possible to find the controlling law, and this done, it would then be possible to investigate the cutting of harder materials over a small portion of the curve, and compare this portion with the corresponding portion of the curve already obtained. The same instrument could possibly be used for tests on such materials as lead, soft white metal, etc.

Another line of experimentation would be to arrange some machine tool, such, for instance, as a lathe, for running at very low speed, say 1 in. per hour; mount a steel disk on this lathe, and take a cut at the circumference of this disk. In this manner the cutting action would be of the simplest kind, as the tool to be used could be a square-nosed tool of greater width than the thickness of the disk, so that there would be no side cut. A moving picture taken at a high rate of speed could then be reeled off at a low speed, and it would probably be possible in this way to visualize what actually takes place in cutting metal. It would readily show whether cutting is merely the result of tension, or whether shear plays a rôle, or whether both are responsible. It would probably show whether the chip leaves the work ahead of the tool point, and whether or not the front end of the tool is in contact with the work. It would probably show many other things besides, and might be made the foundation for a number of lines of experimentation.

The writer believes that the time has come to try to interest as many engineers as possible in the subject of collecting fundamental data in regard to the cutting of metals, but rather than to suggest individually some method by which universities, industrial establishments, and engineers might be asked to coöperate, he prefers that this matter should be discussed by the Society, and would like to have this paper lead ultimately to a systematic effort in this direction, fathered by The American Society of Mechanical Engineers.

MACHINE-SHOP ORGANIZATION

BY FRED G. KENT,[1] CINCINNATI, OHIO

IN this paper it is my purpose to outline briefly the basic structure of an organization for a shop building the average line of machinery. I shall not touch at all on the commercial side of the organization, such as sales, advertising, financial, and purchasing, but will confine the paper entirely to the manufacturing end.

As all my experience has been with concerns in operation for some years before my becoming connected with them, I have always had the advantage of having considerable high-grade material, both in the way of men and equipment, ready at hand to work upon, which accounts for some of the ideas expressed below.

While I have been associated with some very large concerns, I would rather these remarks apply to the shop employing 600 men or less, for a shop of this size, from the very nature of its growth and the volume of business transacted, has just as many, if not more, obstacles to overcome as the larger plant, and is usually in no condition financially to set aside any large sum for betterment work. For this reason it is necessary in a business of this sort to plan any forward move with the greatest care, in order that there may be sure profit in each change made, and all such changes may take place at such times as to cause no interference with getting out the regular product.

This, of course, means rather slow progress, which is apt

[1] Lodge and Shipley Machine Tool Co.

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to be discouraging to the man who is anxious to see things go, but, on the other hand, it has a decided advantage in the fact that the evolution is so gradual that there is very little opposition or unfavorable comment from foremen or workmen inclined to discredit innovations. This in itself is a very important factor toward any reorganization scheme, for, notwithstanding arguments to the contrary, the stability of any shop system depends very largely on whole-hearted coöperation, from the chief executive clear down the line to the sweeper.

Some time ago James Collins made the statement in a magazine article that "during the next few years some of the largest profits in American industry will be saved out of operation. Heretofore our profits have been made, but saving a profit is a different thing altogether." I quite agree with this, and my work for several years has proven to me that hundreds of small details are allowed to take the wrong course simply because they have always gone that way. We have all of us been too much concerned in systems of paying wages, with the object, of course, of getting more work at a lower cost. Sometimes straight piece work has been adopted, and again it might be some one of the several forms of the bonus or premium plan, and in nearly every one the feverish desire to get something started has precipitated action without proper planning, and has brought about useless waste of time and energy, and, in many cases, ill-feeling among the workmen. If for no other reason than that of harmony, let us leave the time-study and wage-payment schemes until we feel sure that we have very nearly gone the limit in stopping other leaks.

My first point is that wage payment, premium schemes, bonus arrangements, etc., should be the last point of attack rather than the first.

Let us suppose that we are going about the reorganization of such a shop as I have mentioned. What is the best course to take? It is my opinion that the easiest way out, and at the same time the one most profitable, is for the directors to place a man of proven executive ability at the head of a military or line type of organization, giving this man plenty of time and a free hand to work out the solution of their problems. This arrangement will prove successful more times than any other.

The selection of a title for the man who is to lead the way is a matter of considerable importance, and, if possible, the position should be a newly created one. For instance, if the chief executive has been known in the past as a supervisor or general superintendent, let the new position be that of Works Manager. Such an arrangement enables the old superintendent to retain his prestige with the men until it may be deemed proper to make a change, and it also starts the new man off with more of a punch.

The question is often asked, "Where can we get the right sort of man?"—and the answer is that he is not half so hard to find as is generally thought. Many a time the man is already in the organization, but he has been so thoroughly "hog-tied" that he has never had a chance to show what was in him.

Assuming that the right man is on hand ready to take hold, if he is a newcomer in the concern he should be given at least two months to get acquainted, first with the owners, carefully analyzing their statements of troubles. After two or three days on this end of the job, let him go out into the shop and get acquainted with the department heads, encouraging them to talk of their troubles, and if possible have them express an opinion as to the causes of failures in the past. Let him drop into the works in the evenings and cultivate even the watchman's acquaintance. He will find that long hours spent alone in the shop are frequently productive of leads of value. Let him walk through the machine and erecting departments on Saturday afternoon, and an occasional Sunday for a time, looking into every corner and cubby-hole. The number of points that can be brought out in a survey of this kind will surprise one who has never tried it. All this is a mere matter of getting acquainted with the job, and it goes without saying that if this point is neglected all future work will rest on an insecure foundation.

The location of the headquarters of the new works manager should be open to all shop employees and the men encouraged to come in. It should, therefore, be in the place most accessible to the works, and it should also be perfectly plain in its appointments. The business to be transacted with the shop can be carried on over common oak desks and bare floors with a far better feeling than it can over mahogany furniture and oriental rugs. The average workman does not care to come with his greasy shoes, soiled clothes and dirty face into an elegantly appointed office to talk about the things the manager ought to know about, and when he does, he is self-conscious and ill at ease, and goes away without half stating his case and irritated because of a feeling that he has been put at a disadvantage.

Now, when the works manager has learned to find his way around without a guide, and the men in the shop have learned to take his presence as a matter of course, let him start the first forward move by analyzing his shop conditions and personnel, and laying down a definite organization. Of course, any organization that he may plan in the start will be changed in minor details many times, but there is no reason why the main structure should not remain practically the same as originally planned.

It is understood, of course, that what one is seeking for in this move is to subdivide the entire plant into a number of different units, placing a definite responsibility upon the head of each unit, and it is understood that the heads of these units will be respected in the positions that they hold, or, in other words, there must be no splitting of authority or going over one's head with orders of any sort. For instance, the giving of orders directly to a workman by a general foreman or anyone else higher in authority is a serious breach of discipline, as it soon weakens the foreman's standing with the men to such an extent that he soon becomes useless as an executive. The same thing holds good, in a much greater degree, in the relationship of the owners to the head of their manufacturing operations. This may seem an insignificant point to bring out in a paper that is only touching the high spots, but I believe that many shops in need of reorganization owe 90 per cent of their troubles to the failure to fix definite responsibility and live up to it.

This subdivision of the shop is readily visualized by means of an organization chart which will give the layout of responsibility as well as the physical layout. In making up this organization chart, I have found that the easiest way is to use round metal-bound cardboard tags distributed on a large drawing board (see Fig. 1).

The first tags made out should contain the names of the main departments. The average typical shop should have the following departments: Works Office, Engineering Department, Pattern Shop, Tool Design and Storage, Tool Making and Repair, Plant Engineering and Power, Machinery, and Erection.

This division of the shop is merely typical, and it must be understood that all sorts of variations are necessary, due to the

varying factor of the personnel from which the organization has to be made. I might say here that I am a very strong believer in using the personal material at hand rather than replacing the old employee by new help.

The next step is to add to each department tag the name of the man who is selected to have charge of that department. With these tags spread out on the drawing board, with two more tags for the Works Manager and an Assistant Works Manager, and a number of smaller tags for the subdivisions of the major departments, the general shop organization begins to take shape.

I want to insert here that the Assistant Works Manager should be capable of assuming the work of the works manager in the latter's absence from the plant, and both the works

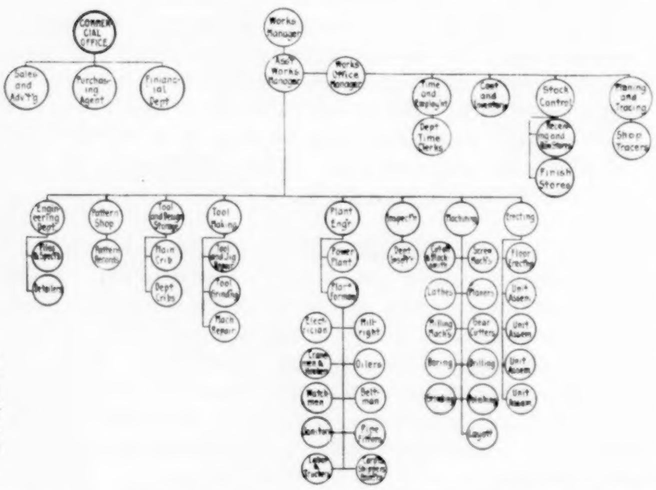

Fig. 1 Typical Organization of Shop with 300 to 500 Employees

manager and the assistant should have as few routine duties as possible. Their time should be spent in planning improvement and in bolstering up the weak points in the organization. A great many men get the idea that organization once done is done forever. On the contrary, the only organization that is final or complete is a dead one. I have cleaned up two plants after several firms of so-called efficiency engineers had had a shot at them. They had gone away after a time, leaving a mass of charts, forms and card indexes which were supposed to have accomplished a complete reorganization. Even if this reorganization was sufficient for the needs of these plants at the time they left, which it was not, it would be foolish to suppose that it would automatically administer affairs for an indefinite period. The business that is managed by live men is always subject to profitable changes.

The balance of this paper is covered by an analysis of the departments enumerated above, beginning with the Works Office, which the author considers the most important division of all, and concluding with the Erection Department.

The author states that the paper just touches the high places, but it outlines the basic structure of an organization for a medium-sized shop building the average line of machinery.

The chairman of the British Engineering Standards Committee, Sir John Wolfe Barry, has accepted the invitation of the Council of the Institution of Civil Engineers of Great Britain to give the James Forrest lecture on Wednesday, May 2.

METAL PLANERS AND METHODS OF PRODUCTION

By CHARLES MEIER,[1] CINCINNATI, OHIO

THE problem of providing the increased speeds and power to develop the possibilities of high-speed steel and to meet the increasing necessity for greater production has been a comparatively simple one in such machines as lathes, drilling machines, boring mills, milling machines in which the cutting is continuous and the motion of the tool is in one direction only. In this type of machine it has meant merely adding power and strengthening parts.

The speeding-up process introduces, however, a vastly different problem in such machines as slotters, shapers and planers, in which the cutting is not continuous and which have a return motion of the tool. The principal limitations of machines of this class, especially the planer, are twofold, *first*, the inertia of the moving mass at the moment of reverse; *second*, the speed at which the tool enters the work. The problem of overcoming these limitations has had the attention of quite a number of engineers, and while considerable progress has been made the complete solution does not seem to have yet been reached.

The evolution of the planing machine has followed along the lines of increased table speeds. The earlier demands were all for a higher return speed, in the belief that great savings could be effected by reducing the idle time consumed in the return of the table.

It next followed that further gains could be made by increasing the cutting speed, owing to the fact that this part of the cycle consumes the greater part of the time involved. The advent of high-speed steel can be credited largely with the marked advance in this part of the development.

After fairly high speeds in both directions were obtained there came the demand for variable cutting speeds. It soon became a recognized fact that to operate a planer having only one cutting speed was both wasteful and detrimental to the best methods of increased production.

This constant change of conditions, and the desire to obtain the highest possible speeds in both directions, led to serious difficulties for which a change in design became imperative.

One of the objections to the speeding-up of the planer was the difficulty encountered at the reverse, namely, the inertia of the moving parts. Several tests were conducted which established the fact that the greater part of the trouble was caused by heavy machine pulleys and their high speeds.

Various types of magnetic, pneumatic and mechanically operated clutch drivers were designed in which the pulleys were not reversed. Our experience with these drives was that they developed the objectionable features inherent to friction clutches, namely, the slippage and wear which take place before the parts are properly engaged. The most successful of these types was the pneumatic clutch.

A few planers were built which embodied heavy springs to overcome the shock at reversing. We designed one machine in which these springs were added into the driving gears, and in another machine the table rack was made floating and held in place by two heavy springs at either end. These designs did not prove satisfactory, owing to the variable pressures while under heavy or light cutting. Also the springs had very little effect at the moment of reverse.

[1] The Cincinnati Planer Co.

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It seemed that none of these arrangements quite met all conditions, and to overcome the difficulties in the standard belt-shifting machines experiments were conducted with lighter driving pulleys. A step which marked quite an advance in this direction was the use of an aluminum alloy for the pulleys instead of cast iron. It was found that not only did this overcome the greater part of the objections to the heavier pulleys, but that higher speeds were possible so that a decided gain was made in the number of cutting strokes owing to the fact that less time was consumed in the reverse. Table 1 gives results of a test made on a 30 x 30 x 14 ft. planer and gives a good idea of the gains effected by the use of aluminum pulleys.

These pulleys were also found to effect quite a saving in power. Table 2 shows a test made on a 76 x 62 x 32 ft. planer, in which the saving in power was about 25 per cent.

The subject of individual electric-motor drive for planers has received considerable attention in the past few years. One type of drive which has been successfully developed is the variable-speed drive. This consists of a 2 to 1 variable-speed motor coupled direct to the top driving shaft of the planer. The speed of this motor is controlled by two separate sets of resistances which are automatically operated by a master switch connected to the shifting mechanism of the planer.

The cutting speed can be varied from 25 to 60 ft. per min., while the return speed may be varied if desired without affecting the cut. The controller handles are set to a predetermined speed before starting. The planer is operated in the usual manner from the tumbler, and the master switch automatically varies the speed of the motor at each reversal. This type of drive has the desirable feature of eliminating the mechanically operated speed variators and is quite simple in operation. It provides a very flexible arrangement when variable speeds are desired. This is especially true on the smaller sizes of planers.

Probably the most interesting motor application to planers in recent years is the reversible-motor drive. While it cannot be claimed that the application of this type of drive is new, it can be stated that the drive approaches more nearly the ideal planer drive than any other method heretofore used. By coupling the motor direct to the first driving shaft, the entire reversing mechanism, pulleys and belts, are eliminated and all the objections before enumerated are successfully overcome.

The motor is an adjustable-speed motor, having a speed range of 1 to 4 so that a large range of cutting speeds from 25 to 50 ft. per min. can be obtained. A double set of resistances is provided making it possible to vary either cutting or return speed independently of the other. This arrangement has also simplified the problem of variable speeds in connection with this drive.

The operating mechanism is handled in exactly the same manner as is the standard belt-shifting type planer, so that no complications are encountered by the operator. Two predominating features in this type of drive are the total absence of belt slippage under heavy cutting and the lower peak loads at the moment of reverse. Table 3 shows the superiority of these two features over the belt drive.

It can be said that the reversible motor drive as applied today furnishes about all that can be desired of an efficient planer drive.

The study of fatigue of the operator and easy control of the machine is receiving quite a lot of attention in almost every machine operation, and there is no doubt but that great possibilities in this direction exist in machine-tool construction.

Power operation of heavy machine parts seems to have found a permanent place in the construction of all classes of

TABLE 1 TEST ON 30 x 30 x 14 FT. CINCINNATI PLANER TO SHOW THE GAIN IN STROKES AND EFFICIENCY OF ALUMINUM DRIVING PULLEYS OVER CAST IRON DRIVING PULLEYS

CUTTING SPEED 40 FT.; RETURN SPEED 90 FT.

Length of Stroke, Ft.	Time Table was Running, Min.	Cutting Strokes with C. I. Pulleys, Weight 56 Lb.	Cutting Strokes with Aluminum Pulleys, Weight 20 Lb.	Number of Strokes Gained	Theoretical Number of Strokes	Per Cent Efficiency of Aluminum Pulleys
2	30	306	350	44	415	84.3
4	30	165	189	24	207	91.3
10	30	76	82	6	83	98.7

TABLE 2 TEST OF 76 x 62 x 32 FT. CINCINNATI PLANER WITH CAST IRON AND ALUMINUM PULLEYS

Amperes Gear Box and Loose Pulley	Amp. Platen in Direction of Cut		Amp. Platen in Direction of Return		Amp. Reverse from Cut to Return		Amp. Reverse from Return to Cut		Length of Stroke, Ft.	Remarks
	C. I. Pulley	Alum. Pulley	C. I. Pulley	Alum. Pulley	C. I. Pulley	Alum. Pulley	C. I. Pulley	Alum. Pulley		
15	20	20	27½	28¾	132½	106¼	91¼	75	0.66	Lengthening stroke from 0.66 ft. to 20 ft. does not alter result 2 amp. either way.
14	22½	20	30	28¾	132½	105	93¾	76¼	20	
16	21½	21¼	30	30	130	105	95	76¼	20	
15	21⅓	20.4	30	29⅙	132½	105	93⅓	76⅙	This line is average.	
4.4	6.3	6	8.8	8.6	39	30.9	27½	22.4	Average Hp.	

TABLE 3 TEST MADE BY GENERAL ELECTRIC CO. ON 60-IN. x 72-IN PLANER

	Single Belt Drive	Double Belt Drive	Pneumatic Clutch Running at 200 r.p.m. on Cut and 600 r.p.m. on Return	Pneumatic Clutch Running at 70 r.p.m. on Cut and 200 r.p.m. on Return	Direct-connected Electric Motor having Cutting-speed Range of more than 2 to 1 and Total Speed Range of 4 to 1
Drive, Hp.	25	25	25	25	25
Stroke, Ft.	8	8	8	8	8
Approx. Cutting Load, Hp.	25	25	24	26	31
Peak Load, Reverse to Return, Hp.	55.5	44.3	75	25	20
Peak Load, Reverse to Cut, Hp.	25	55	36	15	20
Time Return Stroke, Sec.	7.2	7.2	7.6	6.8	5.6
Time Cut Stroke, Sec.	20	20	19.5	16	13.4
Time of Cycle, Sec.	27.2	27.2	27.1	22.8	19
Ft. per Min. Return Stroke	66.6	66.6	63.2	70.5	85.7
Ft. per Min. Cut Stroke	24	24	24.6	30	25.8
Ratio Cut to Return, One to	2.78	2.78	2.57	2.35	2.4

machinery. There is an increasing demand for elimination of lost time between cuts, and this feature has also found its way into the design of planers.

Rapid power traverse is now being generally used in manipulating planer heads in all directions. This is quite a departure from the standard construction in which the heads are operated entirely by hand. Experience has demonstrated that the new practice eliminates a considerable amount of wasted time throughout the day, and that it is also a decided help to the operator, as it saves him from undue exertion and fatigue.

The building of high-grade planers has established itself as an important factor in the machine-tool-building field. Many users seldom realize that, unlike smaller machine tools, the building of a planer requires a more extensive equipment of machinery, as well as a large number of costly fixtures and measuring instruments. The planer is necessarily a large and expensive machine, and proportionately larger returns are obtainable from it than from small machines owing to the higher expense or burden charged against it. The planer, therefore, should receive special attention from the time-study department.

GAS POWER PAPERS

DURING the past few years there have been marked improvements in gasoline-engine construction which have led to the extensive use of the high-speed type, particularly for aeroplanes. There will be a general discussion of this subject at the Gas Power Session of the Spring Meeting together with that of gas-engine regulation. Other papers treat of motor fire-engine tests and motor trucks.

THE PROBLEM OF AEROPLANE ENGINE DESIGN

BY CHARLES E. LUCKE, NEW YORK, N. Y.

Member of the Society

THE problem of the aeroplane engine appeals strongly to every engineer because it is a problem of the lightest power plant. The lightest weight of engine proper per horsepower is to be secured first by obtaining maximum mean effective pressure at maximum speed: in other words, the product of the mean effective pressure and the speed must be a maximum. At the same time the weight of metal per cylinder, or per cubic inch of cylinder displacement per working stroke must be a minimum,—and with both of these factors the engine must be reliable in operation. So far, this reliability factor has been weakest, though lightness has been secured in engines good for short periods of running.

Not only must the metal weight of engine per horsepower be a minimum, but in addition the fuel weight to be carried must also be a minimum because, as can readily be seen, the fuel weight necessary for flights of any length predominates over the engine weight. For example: taking a half pound of fuel and oil per hour per horsepower as a fair value, it is readily seen how quickly that will catch up on engine weight when the latter is 4 or 5 lb. per horsepower.

In undertaking an analysis of the aeroplane-engine problem from the records, the only conclusion that can be drawn is along the line of type. Data are almost entirely lacking. On the question of general engine types, attention might be called to a few points:

The air-cooled motor has entirely failed in comparison with the water-cooled motor,—the reasons are perfectly sound and secure. The 2-cycle engine has given way to the 4-cycle type.

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Fixed cylinders have prevailed over rotating cylinders. Odd cylinder arrangements of queer, freaky forms have all been relegated to the scrap heap in favor of a few modern arrangements. The standard cylinder arrangements of today, which are the survivors of what may be called the inventive period, or at least the first inventive period, are the six and eight cylinders in line and the eight, twelve and sixteen V's.

It really appears therefore that the one valuable result of all our experience has been the selection of a few typical arrangements which we are now compelled to study, as minutely as circumstances permit, for the purpose of standardizing and mechanically perfecting these particular types as standard machines which will run as reliably as our stationary engines and which can be manufactured as economically.

Taking up each of the factors of aeroplane-engine design that seem important, in as specific a way as seems proper, the first one I wish to consider is the value of efficiency and the relation of efficiency to minimum weight.

Plotting hours of running as abscissæ against weight of engine, with fuel and oil, as ordinates, for the air-cooled and the water-cooled types of motor, respectively, so that the intercept on the vertical axis represents the weight of engine metal alone, and the ordinates away from the axis represent the weight of metal plus fuel and oil, one finds that the two curves cross at some period of running beyond which, therefore, the water-cooled heavier engine, because of its lower fuel consumption, becomes lighter in comparison.

The metal weight of the water-cooled motor is about one and one-half times that of the air-cooled motor, and the slope of the combined-weight line of the latter compared with that of the former is as two is to one,—that is to say: the consumption of the air-cooled motor is approximately twice that of the water-cooled motor. These facts are responsible for the crossing of the lines.

Of the conditions for efficiency which bear upon this question of fuel weight, and which have led to the selection of the water-cooled motor as a type, the first is the compression. The higher the compression the higher the efficiency, and there is no limit until preignition occurs. Statements will be found in textbooks to the effect that there is a limit, but they are the results of mistakes in interpretation, and are erroneous. The amount of compression possible is limited, however, by the metal temperature and by the temperature of the mixture as admitted. Naturally, the warmer the mixture during suction, the sooner it reaches ignition temperature by compression. Therefore, suction heating is a limit. Again, the interior metal temperature, if it is high (as it is always), may cause trouble by contact with the mixture during compression, and

some portion of the mixture may be brought to its ignition temperature by hot-wall contact long before the main mass is brought to this ignition temperature by compression alone. It requires only one such hot spot to wreck a well-laid plan.

The next factor in efficiency is the mixture quality, and in this there are the following controlling elements: first, mixture proportions. Any excess fuel means direct waste, but it also means carbonization and fouling. Excess air quickly makes the mixture practically non-burnable. Therefore, mixture proportions must be accurately controlled—more accurately than is possible with any existing carburetor. Carburetors are not yet satisfactory, and as soon as satisfactory carburetors are secured from the standpoint of proportionality of the mixture, we may expect to see a further reduction in fuel consumption and more reliable operation.

Dryness of mixture is a matter of coördinate importance with mixture proportions. When mixtures are wet, that is not completely vaporized, the air and fuel cannot be uniformly distributed to the various cylinders by the manifold system. One cylinder will get a different charge from another, as can be easily proved by pressure gages. There are rarely two cylinders alike as to maximum pressures on a multi-cylinder engine using wet mixtures. Drying of the mixture will cure that fault, and also cure the carbonization that comes from the vaporization of the liquid in the presence of the burning gas when it has been admitted to the cylinder in a liquid state.

The third factor of the mixture question is homogeneity. However accurately the mixture may be adjusted as to fuel and air ratio, however carefully the mixture may be distributed, cylinder to cylinder, the fact remains that, in order to produce economical results, the charge in any one cylinder must be uniform in every cubic inch of it. It is not sufficient that the right amount of air be in the cylinder even if the fuel is vaporized when the latter is all in one corner.

Following mixture quality, the next factor in efficiency is rate of flame propagation with reference to piston speed. It can be shown that the explosion line of the indicator card following compression must be maintained vertical for maximum efficiency. Now, the rate of propagation is the one factor that tends to hold it vertical. If the propagation rate is high enough for a given piston speed, so that the explosion line is vertical, the efficiency will be high. But should the piston speed exceed a certain value, then the explosion line will begin to lean toward the expansion line, until by and by it becomes horizontal and merges into the expansion line, with a consequent large loss of work area and low efficiency or high fuel consumption. Therefore, there is for every given mixture a limiting piston speed that cannot be exceeded without destroying efficiency, and we are now approaching that speed in aeroplane engines.

The next related factors are mean effective pressure, and speed. These are the prime factors for the output of a cylinder.

If the mean effective pressure were constant, then horsepower with reference to speed would follow a straight line. The mean effective pressure is not constant as the speed varies, however. Therefore, plotting horsepower against speed gives a curve having the general form of concave downward and consisting of several separate portions, each worthy of study. There is usually a straight portion over a given speed range, during which the mean effective pressure is constant. For lower speeds the mean effective pressure is lower, and for higher speeds the mean effective pressure is again lower. From the point where, with increasing speed, the straight line becomes a concave-downward curve, the mean effective pressure is decreasing as speed increases, until at the point where the tangent to the curve becomes horizontal, the rate of increase of speed is exactly equal to the rate of decrease of mean effective pressure. At a little higher speed mean effective pressure decreases faster than speed increases, and finally the curve drops down toward zero power.

So much for the facts. An analytical engineer cannot be content with those facts, however, but finds it necessary if he is to apply a cure to go behind the facts to ascertain the reasons. The first step in doing that is to determine the volumetric efficiency of the engine by measuring the air and fuel, and comparing the total volume of mixture taken in, with the piston displacement. If the volumetric efficiency be plotted against the speed, much light is thrown on the situation. In the first place the volumetric efficiency falls off in the region of very low speed, where the mean effective pressure is low; it is constant over the region of constant mean effective pressure, where the horsepower speed line is straight, and then at some high speed it again decreases. It is clear, therefore, that curvature of the horsepower-speed line is due to a corresponding variation of volumetric efficiency. It may be found, however, that at some high speed the horsepower-speed line falls before the volumetric efficiency. This calls attention to the fact that the falling-off of mean effective pressure at high speeds may not be due primarily to volumetric efficiency but to other causes, and recognition of this starts a search for those causes.

The first of these causes is too slow a combustion, or too high a piston speed. That is to be corrected by adding an additional ignition source, or by moving the spark plug from a side wall to a center point. Igniting at more than one point or at a more central point will cure this defect, and again cause the dropping points of both horsepower-speed and volumetric efficiency-speed curves to lie on the same speed line.

Again, it will be found that a change in the valve setting changes this mean-effective-pressure curve at both ends, but every change in the valve setting also changes the mean effective pressure, and the volumetric efficiency is itself the direct measure of whether or not one has the best valve setting.

Now, it is curious that most people have played with cams and adjusted them back and forward by guesses, and have never bothered about the air meter, which is the only positive means of arriving at best cam forms and valve timing for sustained mean effective pressure at high speeds.

Many more analyses along the above lines could be given, but enough has been said to call attention to this most important means of studying the problem of maximum power at high speed, not only revealing what is the matter but pointing out clearly the direction in which to correct the fault.

So much for efficiency and mean effective pressure, or efficiency and horsepower per cubic foot of cylinder. Those two factors bear directly on the fuel weight to be carried and the output per cubic foot of cylinder. What will be the weight of that cubic foot of cylinder? This has to be judged both by qualitative and quantitative analysis. It is impossible to give any quantitative analysis without long mathematical treatment, so I will undertake only the qualitative analysis.

The first point in qualitatively analyzing unit metal weight of the multi-cylinder engine is to recognize that the engine can be divided laterally by planes into sections of one cylinder each. The end sections are the same as each other, but are different from the intermediate sections. Therefore, to study qualitatively the relative weights of two typical constructions,

the mind must be concentrated upon these sections, each one of which includes a cylinder, a piece of frame, a piece of shaft and the other parts that go with the section.

From this point of view, consider multiplication of cylinders in line vs. radially or circumferentially. It will appear that the weight of the cylinder, piston and connecting rod, is just the same no matter how the cylinders are arranged, but the frame weight and shaft weight are reduced by any multiplication. It is clear also that, other things being equal, the lighter arrangement is circumferential rather than longitudinal multiplication.

Now, going back to the history of the situation, we find every conceivable combination has been tried, but these have finally crystallized to not more than two kinds, giving the V-type engine and the engine with cylinders in line.

Considering the effect of cylinder diameter upon unit metal weight, it will appear that from the unit weight standpoint the cylinder diameter should be as large as possible, because the wall thickness of a cylinder is always greater than necessary for the stress for other structural reasons. A 1/16-in. cylinder of steel will not be stressed over, say, 10,000 lb. per sq. in. The cylinder could be made much thinner than this and still have a good working stress if there were not other structural objections to it. This being the case, the larger the cylinder for a cubic foot of displacement the less the unit metal weight in the wall, and the only limit to large diameter is good running.

Considering the stroke, as this is increased the metal in the cylinder piles up endwise, or axially, too fast with reference to volume, and therefore for minimum unit metal weight, the shorter the stroke the better. In proportion, we are using, normally, shorter strokes in aeronautical motors than in automobile engines for that reason.

Again, as affecting the metal weight, we have the connecting rod length. Clearly, the shorter the connecting rod the shorter the frame, and therefore the more metal saved. The only objection to the shorter connecting rod is an excessive angularity, which introduces stresses requiring metal thickening in other places.

The number of cylinders should be as large as possible up to the point where the weight of the connecting parts has to be increased. A 2-cyl. engine has less than twice the weight per cubic foot of displacement than a single cylinder, for the reason that the number of end supports for the shaft, etc., is not increased. Similarly a 3-cyl. has less than three times, a 4-cyl. less than four times, and so on; and the weight per cubic foot of displacement gets less and less until a certain number of cylinders—somewhere about six—is reached where the shaft diameter and the weight of the frame must be increased so as to retain the necessary stiffness, whereupon the saving in weight by multiplication is neutralized. This appears to be about the limit of saving by line multiplication.

The metal weight per cubic foot of cylinder displacement has to be taken up along the lines indicated, extending the study to the form vs. weight of each individual member. It will appear, as one examines the forms of these individual members, that one form is clearly susceptible of less weight than another—even with the same working stresses or with equal factors of safety.

The first of these studies should be undertaken with reference to cylinders. The first cylinders built were made of cast iron, with head, cylinder and jacket cast in one piece, and the valves being arranged in a side pocket—the ordinary T- or L-head construction. It is clear that the weight of the valve pocket is detrimental. The first step in any cylinder-weight reduction, then, is to take that pocket away, retaining the cast cylinder (on the assumption that we do not know how to make any other kind) and putting the valve in the head. This results in the valve-in-head construction, which is now practically universal, but which, strange to say, it took six or seven years to realize.

A similar instance of slow realization of facts exists with reference to the cast-iron jacket wall, which has no other function than to hold water. Cast iron for that purpose, especially in an aeroplane engine, is wasteful of material, so the next step is to get rid of the cast iron. When one stops to think how it is to be done, a structural difficulty becomes apparent, and therefore one must not too readily condemn the holding on to the cast-iron jacket. The difficulty is of course the necessity of providing openings for the intake or outlet from each valve, an igniter plug hole and at least two pipe connections for the jacket, and in an aeronautical engine under heavy stress there is some driving gear which requires fastenings. This naturally tends toward the use of a casting.

Suppose such a casting is used, with inlet and one exhaust valve each with a port leading out, and such valve seating in the head which turns down to form the cylinder; then the casting may be led around the top, forming the enclosure of the head jacket and joining the several outlets and coming down outside the cylinder. The cylinder-head jacket casting ends in the form of a skirt at about the level of the valve deck, and to this end a tube jacket can be added by any one of several possible fastenings. That is the next step: cast iron for the cylinders, head and head jacket in a one-piece casting, but with sheet metal for the jacket over the cylindrical barrel. It is a logical step, but it took several years to reach it just the same.

Proceeding along the same line of weight reduction, the next step is to cut away this cast iron joining the ends of the ports and forming the wall of the head jacket, and substitute sheet metal welded to the ports by the oxygen welding system. Wherever there are connections to be made for attachment of gears, there must be some additional supports welded or brazed on. The cast-iron cylinder is still there, and with cast-iron ports.

There is a fundamental objection to a cast-iron cylinder for aeronautical work, and it is a perfectly valid one. Cast-iron cylinders do not have to be very thick to be amply strong, so far as the gas-pressure stresses are concerned, but the fact remains that so long as they are cast iron, no one knows whether they are good cast iron inside or not, and the use of cast iron cut down to ⅛ in. in thickness incurs taking some chances. Hence attention is turned toward steel.

Drawn steel or forged steel is a reliable material and a logical selection, so designers have sought means of using it; but when one stops to think how to use a drawn-steel tube for a cylinder, and get the necessary attachments on it, one soon recognizes that the matter is not so easy as it looks. That is the reason the adoption of the steel cylinder was so long delayed.

There are now several schemes developed for steel cylinders. The first of these is a steel cylinder of a drawn tube formed without a head, screwed into a separate head carrying the ports and the head jacket cast in one piece. This is rather a satisfactory way of attaching a head, but it involves more than one difficulty. When such a screwed head is set up against the shoulder, it is not at all clear just where it is going to stop; and to secure the proper position one must either scrape the faces or shim them—neither of which is a nice job. A further objection is the considerable weight of the cast iron in a rather

complicated casting, and also the inner wall of that cast iron is a stress wall, the stress of which must pass through the thread to the cylinder. There is no objection to using a casting if it is not stressed, but a casting under stress is not satisfactory and is to be retained only in the absence of something better.

Complete elimination of castings has been tried by using all steel and sheet metal welded together, but this did not prove satisfactory for a very interesting reason. A flat sheet-metal head on which the valves are seated will not remain flat, and a round valve seat will not stay round. Such sheet metal tends to warp out of shape, and with it the valves will not stay tight. However, the material does not break, which is something worthy of thought.

To eliminate the weld between the steel cylinder and head, another construction was developed. In this, a seamless drawn-steel shell with head just like a cartridge is used, and two holes are arranged in the head to seat the valves. It is evident that this is a structure which is sound against all kinds of stresses. It still has some of the difficulties of warping the seats, causing leakage of the valves; and when a valve leaks the amount of heat developed is tremendous. Once a valve starts to leak, it is only a question of a short time before it will be completely destroyed.

The particular construction of cylinder just described is rather difficult to attach to its jacket ports. It is interesting to note one case at least in which a satisfactory attachment has been worked out, and that is the Hispano-Swissa engine, now used on the European war front, and now also being built in this country. In this particular engine the entire outside of the cylinder is threaded, and the cylinders are screwed into an aluminum casting which is double-walled just like the cast-iron block casting of an automobile engine. The thread performs the double purpose of holding the cylinder in place and bringing its head up against the aluminum cast head which carries the ports, and also acting as a thermal bridge between the metal of the cylinder and the metal of the aluminum casting which carries the jacket water. Without the latter there would be poor thermal contact and overheating of the cylinder. While this construction is not entirely satisfactory, it is nevertheless very interesting and suggestive. It immediately calls attention to the fact that a water jacket may be made of an aluminum casting and the ports formed just as easily as in iron, the steel interior carrying the stress due to the interior gas pressures.

It is, however, quite feasible to get rid of the double aluminum wall down along the cylinder barrel into which this steel cylinder is placed and which carries the ports above, by leaving out its interior wall and retaining the outside, or even by stopping the wall just below the head as a skirt to take a short thin tube which may itself be of aluminum, ending at the bottom in a cast stuffing-box ring to act as a joint against the steel cylinder. That, so far as I know, represents the last word in this direction, the steel cylinder head being bolted up to the aluminum head-port casting at the valve seat bases, and not just pressed up against it by a remote thread.

Finally, there is to be noted the one-piece steel-forging construction for cylinder, cylinder head, ports and ignition holes, surrounded by a sheet-metal welded jacket, a very satisfactory though expensive construction.

These heads are themselves a subject of considerable study. We have first a plain head in which the valve inside diameter is half the cylinder less the width of seat, and half the bridge between the valves. Both valves have stems pointing upward and parallel. The plain cylinder, then, which can be made of a plain seamless-drawn steel cartridge, and which is so desirable structurally, limits valve diameter, and this is a factor against it. Valve diameter is a strong influence in volumetric efficiency and weight of charge, controlling, as it does, flow-resistance conditions. Naturally, designers must get the volumetric efficiency as high as possible by keeping flow resistance as low as possible. Therefore, the tendency is to go towards larger valves than is possible with the previous arrangement.

One variation in form for this purpose is the flat bulged head where the valve diameter is larger than before by the amount of the bulge. The flat bulged head is a very desirable thing for larger volumetric efficiency and higher mean effective pressure, but offers some difficulty in manufacture when one is making a one-piece seamless drawn-steel job, but not a serious difficulty.

Another suggestion for getting the same result is to bulge this head upward in the form of two flats and put the valves on the two inclines. It is perfectly clear that a very large increase in diameter can be secured in this way. The valve stems in this case are not parallel but diverge at any angle and the limit is reached when the angle is 180 deg., in which case they are horizontal.

The question of block arrangement of cylinders and their jackets vs. separate units, deserves some attention. In some cases each cylinder with its jacket and head is entirely separate. In other cases the jackets are cast or welded in a block form, around more than one cylinder—sometimes two and sometimes four, and in some cases six. It is clear that the more cylinders included in the jacket block, the less will be the weight of the jacket, because the length of the tangent to two jacket circles is less than a half circumference. But there are objections to the block, and in some cases it may not pay to use it.

In a case in point, a cast-aluminum block jacket was set down over four steel cylinders which were bolted to the frame by their usual flanges and studs. These cylinders gave trouble on the outer flanges, the end studs breaking off or pulling out. The trouble was caused by the crankcase running hot, expanding; and the aluminum-block cylinder casting running cool, because it was water-jacketed, not expanding. The cylinders being bent inward tore the stud ends right out.

Another point: the steel cylinder is naturally flexible, and it belongs—in fact the entire motor belongs—to that class of structures which should properly be termed flexible, exactly similar to bridge structures.

These flexible motors weave just as the engine of a steamship weaves. To attempt to hold one against springing is to attempt what is practically impossible. The cylinders of aeroplane engines should all be perfectly free to go as they will, and not be held on the top in any way. All the block arrangements of cylinders of the sort just described, are therefore objectionable.

Steel cylinders have a natural spring and give to them, and if let alone they will serve well, but attempting to secure them may result in serious distortions, or in highly localized excess stresses.

Proceeding in the same qualitatively analytical style, the complete paper takes up successively the problems of the piston, valves, valve gears, frame, etc., indicating how a gradual realization of conditions has led to modifications of design, and pointing out factors not even yet considered and making suggestions for meeting them. For instance, in connection with the valves the author makes a thermal study of the problem which, he says, has not been undertaken by anyone in the shops. He does the same for the piston, and the

crankcase he analyzes from its consideration as a stress member.

The paper sums up with the pointed statement that the aeronautical engine is emerging from the stage of invention to the stage of design; as a light, high-tensioned steel structure, consisting of seamless tubing and forged or welded steel parts, possibly formed in drop-forge dies. Add to that steel stress structure certain members, such as the piston, exhaust valve and guide, designed primarily for heat-flow conditions and not for stresses. Add to that again certain closing members, such as the ports for the intake and exhaust, which can be very properly cast in aluminum; and the oil crankcase closure, which can be made of any desired materials.

TEST OF A MOTOR FIRE ENGINE

By HORACE JUDD, COLUMBUS, OHIO

Member of the Society

DURING the past ten years the city of Columbus, Ohio, has remodeled many of its horse-propelled steam fire engines and equipped them with motor-driven trucks so that now more than 70 per cent are motor-driven. The city also has two complete combination gasoline motor-driven and pumping units. One of these combination units, put into service in April, 1916, was loaned to the Ohio State University through the courtesy of the Columbus Fire Department for a more extended test than could be undertaken during the acceptance trials by the Inspection Bureau.

In view of the importance and value of the motor-driven engine in getting under way and reaching the fire, as well as the ability to change the motor instantly from propulsion to pumping, the writer offers the results of a performance test on this motor fire engine to those interested in fire prevention.[1]

The motor fire-engine unit was manufactured by the Seagrave Company, Columbus, Ohio, and consists of a motor-driven, direct-connected, centrifugal pumping unit combined with a hose truck. (Fig. 1.)

The motor is a 4-cycle, water-cooled, six-cylinder motor, 79.3 hp., A.L.A.M. rating, and of rugged construction to meet the requirements of fire service. The cylinders are vertical, T-head, cast separately, with integral water jackets. Cylinder bore is 5.75 in., stroke 6.5 in. The crankcase is parted horizontally through the plane of the crankshaft, the upper section supporting the cylinders and crankshaft bearings and the lower section easily removable and forming a reservoir for oil. There are two cam shafts, one on each side of the motor, with the cam gears located in the forward end, encased but easily accessible. The intake and exhaust valves are 2.625 in. in diameter with 13/32 in. lift.

Forced feed lubrication is used. The cooling water is supplied by a separate centrifugal pump operated from the cam shaft. The carburetor is of the float-feed type with automatic auxiliary air intake and is controlled by the throttle lever. The ignition is of double type, (*a*) Bosch high tension, waterproof magneto for one set of spark plugs, (*b*) current from a storage battery through a timer to the second set of spark plugs.

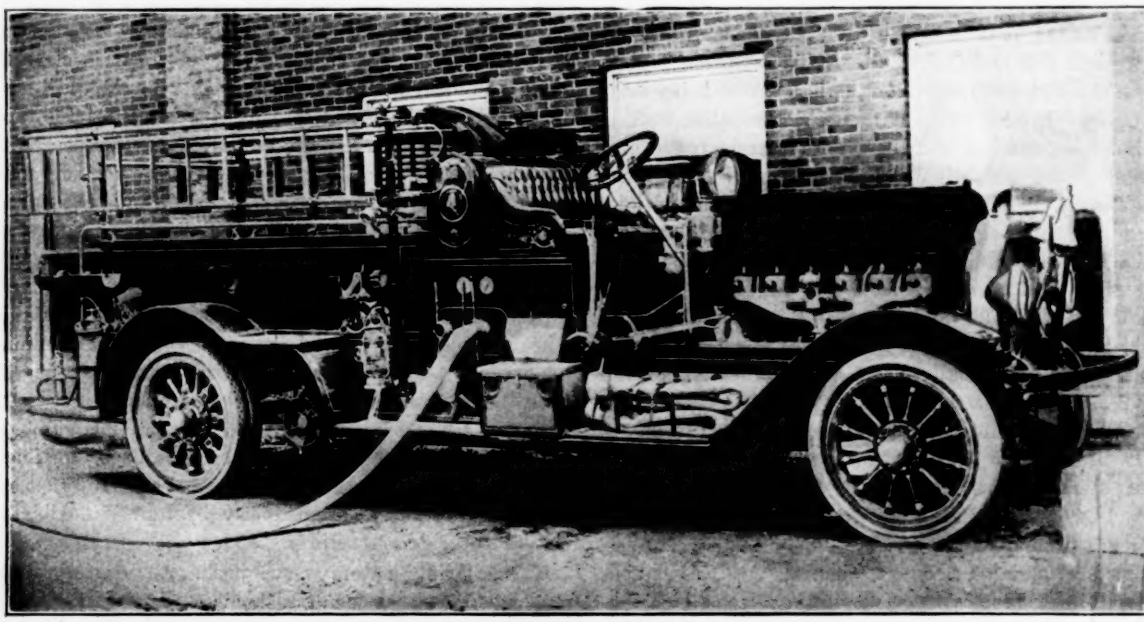

FIG. 1 THE MOTOR FIRE ENGINE

The centrifugal pump (Fig. 2) is a 4-stage (two stages for each impeller) turbine pump mounted under the driver's seat about midway between the front and rear axles. The casing is of bronze and includes in one piece the guide, or diffuser, vanes, and the water passages connecting the successive stages. The two bronze impellers are mounted on a hollow steel shaft which fits over the drive shaft to the differential and is driven by hardened steel gears which can be thrown out of mesh when the engine is on the road.

Each impeller has 12 vanes 1 in. wide and 9/16 in. net depth of water passage between the vanes. There are six diffuser vanes surrounding each impeller. (Fig. 3.) The water enter-

For presentation at the Spring Meeting, Cincinnati, Ohio, May 21 to 24, 1917, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained by members gratis upon application. All papers are subject to revision.

[1] This paper is based on the results embodied in the thesis work of Messrs. E. W. Leatherman, H. V. Walborn, and E. R. Wilson, graduates in Mechanical Engineering, Class of 1916.

ing at the center of the pump passes into the first stage on the inner half of one propeller, is thrown out by centrifugal force through the diffuser vanes and, passing around the impeller through the water passage, enters the second stage on the other side of the same impeller. From the second stage it enters the third stage on the inner side of the second impeller and is discharged into the other side of the impeller

usual range of pressures and with such sizes of fire nozzles as are commonly used.

b The fuel consumption of the engine.

Such a series of tests required the accurate measurement of the fuel used, the water pumped, and the pressures maintained at engine and nozzle.

The tests were carried on in the hydraulic laboratory of the

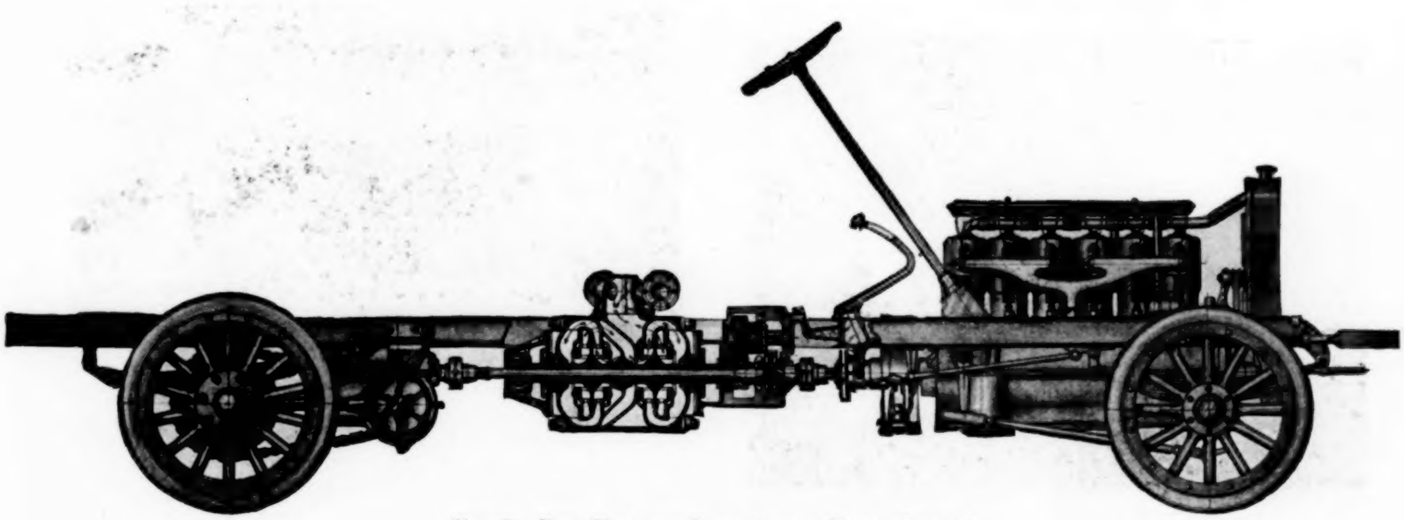

FIG. 2 SIDE VIEW OF CENTRIFUGAL PUMP CHASSIS

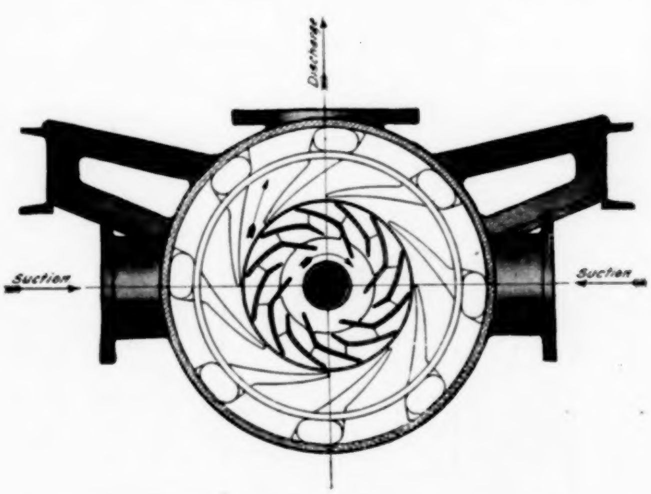

FIG. 3 SECTIONAL VIEW OF ONE STAGE OF PUMP SHOWING IMPELLER AND DIFFUSION VANES

(fourth stage) and from thence it passes into the discharge line. Since the water enters both impellers on the inner side the end thrust is practically eliminated, although end-thrust shaft bearings are also provided. Two suction connections and three discharge connections are provided.

When necessary the pump may be primed by means of a rotary vacuum pump, which will exhaust the air and enable the pump to be put into operation in about 20 sec.

The speed ratio of the pump and engine is 2.06 to 1. The speed range of the motor during the tests was about 800 to 1100 r.p.m., corresponding to a speed range of the pump of about 1650 to 2270 r.p.m. The rated capacity of the pump is 750 gal. per min. at 120 lb. net pressure at the pump discharge.

The purpose of the tests may be outlined as being to determine:

a The capacities of the fire engine when working against the

University, where the water was taken from one of the large cisterns, or bays, 25,000 gal. capacity, as shown in Fig. 4, through three lengths of 5-inch standard rubber suction hose, and was discharged through the desired length of hose line, first into a series of tumbling bays and finally into the suction bay after passing through an 8-in. by 20-in. standardized rectangular weir. The discharge of the nozzles was also read at the jet by means of the pitot gage, or piezo-

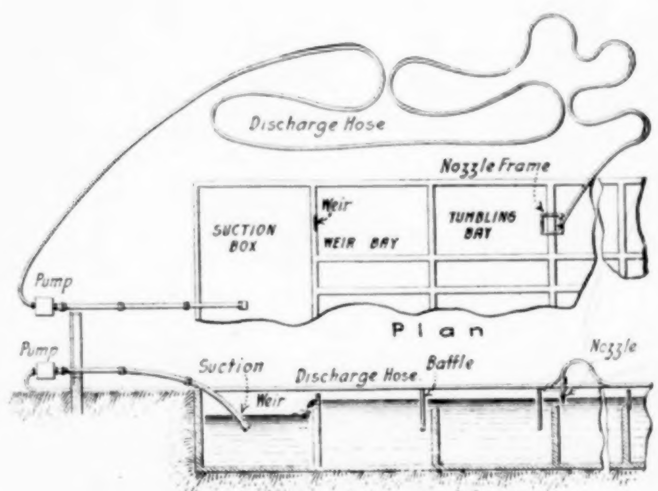

FIG. 4 ARRANGEMENT OF APPARATUS

meter, now widely used in fire-service work to give instantaneous readings of the nozzle discharge. The gasoline used was weighed on carefully calibrated platform scales. The pressures at the engine were taken by the regular service gages and their readings corrected for error. The pressure drop in the hose line was taken by means of a specially con-

structed ring connection for the pressure gage which was located at the hose coupling as shown at *A* in Fig. 5.

The discharge hose was taken from the city service and had seen considerable use but was in fair condition; it was rubber-lined cotton hose with nominal diameter of 2.5 in. and average actual diameter of 2 11/16 in. The smooth conical nozzles, shown in Fig. 6, were taken from the regular equipment of the engines. The sizes chosen were those most commonly used in the city fire service.

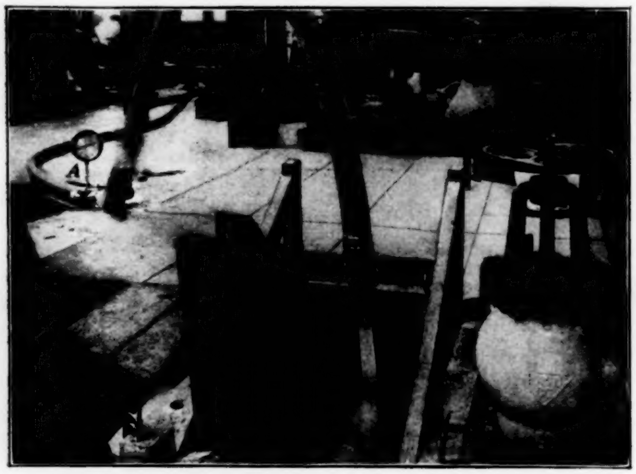

FIG. 5 FIRE STREAM FROM TWO-HOSE SIAMESE UNION

During the test the pump was quickly brought up to running conditions, and with a full gasoline tank the runs were started and continued for 30 min. for the runs with double line using Siamese hose connection, and for 20 min. for the runs using single-hose lines. At the completion of the runs the engine was stopped at the instant and the gasoline tank refilled, and the amount put in was taken as the equivalent of the amount used.

The Siamese hose union was a 4-hose connection, but in this

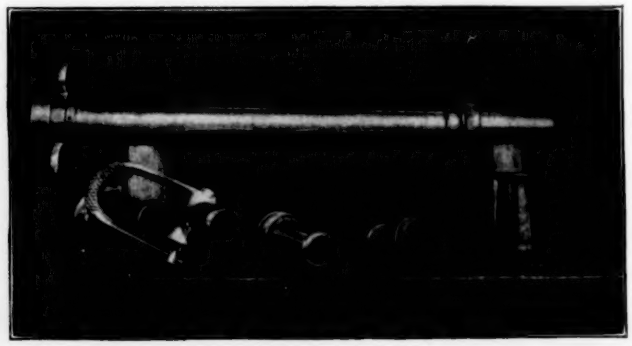

FIG. 6 PLAY PIPES AND SMOOTH NOZZLES

case was connected to the pump with but two 250-ft. lengths of 2.5-in. hose. To the Siamese union was attached the 12-ft. length of 3.5-in. hose with the play pipe and the 1.5-in., 1.75-in., and 2-in. smooth nozzles. Single-hose lines, both 250- and 500-ft. lengths, were used with 1.125-in., 1.25-in., and 1.375-in. nozzles. The range of discharge pressure carried at the pump was from 95 to 250 lb.

Readings were taken for the whole run of the gasoline used, every five minutes of discharge pressure at the pump, the

TABLE 1 AVERAGE DATA AND RESULTS FOR MOTOR FIRE ENGINE, COLUMBUS FIRE DEPARTMENT, COLUMBUS, OHIO

DIAMETER CYLINDER, 5.75 IN.; NO. CYLINDERS, 6; DIAMETER OF HOSE, 2.69 IN.; STROKE, 6.5 IN.; NO. OF CYCLES, 4; A.L.A.N. RATING, 79.3; GASOLINE, 59.8 DEG., BAUME, 19,000 B.T.U. PER LB.

Item	Siamese connections			Two 1.25 in. on single lines. $d=1.246$ in. Area=0.00847 sq. ft.			One 1.125 in. on 500-ft. line. $d=1.121$ in. Area=0.00685 sq. ft.			One 1.25 in. on 500-ft. line. $d=1.246$ in. Area=0.00847 sq. ft.			One 1.375 in. on 500-ft. line. $d=1.37$ in. Area=0.01024 sq. ft.		
1 Number of run	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2 Revolutions per minute; engine	981	954	966	812	884	969	772	1,000	1,132	770	995	1,116	768	997	1,096
3 Revolutions per minute; pump	2,020	1,965	1,990	1,674	1,820	1,995	1,590	2,060	2,335	1,586	2,047	2,300	1,582	2,055	2,258
4 Suction by gage, ft.	14.84	15.88	18.7	15.88	17.23	19.05	7.93	9.75	11.32	7.48	10.43	12.48	7.93	10.78	11.68
5 Suction by gage, lb.	6.43	6.88	8.09	6.88	7.46	8.25	3.43	4.22	4.90	3.24	4.52	5.40	3.44	4.67	5.06
6 Suction (measured) ft.	5.25 (equals 2.27 lb.)														
7 Discharge pressure, lb.	157.3	133.5	121.9	95.0	113.0	134.0	117.0	197.4	249.6	116.7	193.5	242.0	115.7	196.0	236.2
8 Discharge head, ft.	363.5	308.0	281.7	219.2	261.0	309.3	270.0	455.0	575.0	269.0	447.0	558.5	266.5	452.0	544.5
9 Total head, ft.	378.3	323.8	300.4	235.1	278.2	328.4	277.9	464.8	586.3	276.5	457.4	571.0	274.4	462.8	556.2
10 Total head, lb.	163.8	140.2	130.1	101.8	120.4	142.2	120.3	201.2	253.8	119.7	198.0	247.2	118.7	200.3	240.8
11 Static pressure at nozzle, lb.[1]	95.5	62.3	45.5	44.0	51.9	61.5	51.5	85.0	106.8	40.0	58.2	69.3	35.0	47.5	56.5
12 Static head at nozzle, ft.	220.8	144.0	105.2	101.7	120.0	142.1	118.8	196.0	246.0	92.3	134.0	159.6	80.7	109.5	130.2
13 Length of hose lines (2.5 in.)	Two 250 ft.				Two 250 ft.			One 500 ft.			One 500 ft.			One 500 ft.	
14 Drop in pressure in one 2.5-in. line, lb.	61.8	71.2	76.4	51.0	61.1	72.5	65.5	112.4	142.8	76.7	135.3	172.7	80.7	148.5	179.7
15 Drop in pressure per 100 ft. one 2.5-in. line, lb.	24.7	28.3	30.3	20.2	24.3	28.4	13.0	22.3	28.4	15.2	26.9	34.3	16.2	29.5	35.5
16 Gallons per minute	637	693	745	620	636	720	246	322	360	264	335	383	275	363	399
17 Cubic feet per minute	85.2	92.6	99.6	82.8	85.1	96.2	32.9	43.1	48.2	35.3	44.8	51.2	36.8	48.5	52.9
18 Pitot gage reading, lb.	94.9	61.25	43.3	45.6	56.5	64.5	48.5	81.5	105.0	35.0	57.5	71.5	29.0	46.8	57.3
19 Gal. per min. from pitot reading	356.0	718.0	788.0	624.0	699.0	747.0	262.0	340.0	384.0	275.0	353.0	393.0	303.0	384.0	425.0
20 Water horsepower of pump	60.7	56.8	56.7	36.8	44.8	59.6	17.4	37.8	53.2	18.5	38.8	55.3	18.6	42.4	55.7
21 Theoretical velocity at nozzle, ft.	.....	.....	.....	83.4	90.7	98.6	89.3	114.5	128.4	79.5	95.8	104.6	75.0	87.95	95.9
22 Actual velocity at nozzle, ft.	.....	.....	.....	81.5	83.7	94.7	80.1	104.9	117.0	69.4	88	100.8	60.2	78.9	86.1
23 Coeff. discharge of nozzle (including play pipe)	.....	.....	.....	97.5	92.4	96.0	90.0	91.4	91.2	87.2	91.9	96.6	82.0	89.7	89.6
24 Coeff. discharge of nozzle (by pitot gage)	97	96.6	94.5	99.0	91.0	96.3	94.0	94.6	93.6	92.7	94.9	97.6	90.8	94.5	94.0
25 Gasoline per hour, lb.	86.9	80.0	75.7	52.4	57.5	73.4	30.8	46.6	81.0	35.5	58.2	80.1	31.6	52.0	95.8
26 Gasoline per hour, gal.	14.0	13.0	12.3	8.51	9.34	11.92	5.00	7.57	13.16	5.76	9.45	13.01	5.14	8.45	15.56
27 Gasoline per hour per water hp., gal.	0.231	0.229	0.217	0.231	0.208	0.20	0.287	0.20	0.247	0.306	0.243	0.236	0.276	0.199	0.277
28 B.t.u. per hour per water hp.	27,020	26,780	25,390	27,020	24,350	23,400	33,580	23,400	28,900	35,800	28,430	27,603	32,260	23,289	32,400
29 Duty per 1,000,000 B.t.u., million ft.-lb.	73.25	73.95	78.0	73.28	81.3	84.6	58.98	84.6	68.50	55.30	69.65	71.75	61.37	85.06	61.13

[1] For Siamese connection, this gage is located at end of 2.5-in. hose, 12 ft. from nozzle

revolutions of the motor, the pressure drop in the line, and every minute and a half of the weir readings.

DATA AND RESULTS

The average values for *the observed data and the calculated results* from these data will be found in Table 1.

Fig. 7 represents the *important results for the motor fire engine,* as a unit. Here are shown the total gallons of gasoline used per hour for water horsepowers at the pump, ranging from 20 to 60; the gallons of gasoline used per hour per unit horsepower; the number of heat units supplied, and the duty of the pump.

The number of heat units is taken as equal to 117,000 B.t.u. per gallon (59.8 deg. Baumé, 0.738 specific gravity, 19,000 B.t.u. per lb.).

Duty is defined as the number of foot-pounds of work done per 1,000,000 B.t.u. supplied.

$$\text{Duty} = \frac{60 \times 33{,}000 \times 1{,}000{,}000}{\text{Gal. gasoline per hp. per hr.} \times 117{,}000} = \frac{16{,}920{,}000}{\text{Gal. gasoline per hp. per hr.}}$$

The maximum capacity obtained during the test was 745 gal. per min., at 122 lb. pump discharge pressure with a 2-in.

TABLE 2 MAXIMUM CAPACITIES FOR VARIOUS SMOOTH NOZZLES UNDER CONDITIONS OF TEST FOR MOTOR FIRE-ENGINES

Diameter nozzles, in.	Discharge press. at pump, lb.	Maximum capacity by weir, gal. per min.	Pitot gage readings, lb.	Capacity by pitot gage, gal. per min.	Deviation of pitot gage from weir, per cent	No. and length of hose line, ft.
1.121	249.6	360	105.0	384	6.4	One 500
1.246	242.0	383	71.0	393	2.4	One 500
1.370	236.2	399	57.3	425	6.0	One 500
1.500	157.3	637	94.9	656	3.0	Two 250, with Siamese union
1.750	133.5	693	61.3	718	3.4	Two 250, with Siamese union
2.000	121.9	745	43.3	788	5.5	Two 250, with Siamese union
Two of 1.246	134.0	720	64.5	747	3.7	Two 250
Average	.....	...	....	...	4.3	

The capacity as indicated by the pitot gage is seen by Table 3 to be on the average 4.3 per cent higher than that by the calibrated weir.

nozzle attached to a Siamese union with two hose lines each 250 ft. long, as shown in Table 2. This discharge is slightly below the rating of 750 gal. at 120 lb. net pump discharge pressure, and is accounted for by the fact that a 2-hose line instead of a 3-hose line was run from the engine.

The gasoline used by the motor fire engine may be read from the total gasoline curve, Fig. 7. The range of water-horsepower output was from 18 to 60 hp., with most of the tests grouped about 18, 40, and 55 horsepowers.

The average results as read from the curve are as given in Table 3.

TABLE 3 AVERAGE RESULTS FROM FIG. 7

Water-hp. output	Gasoline per hr., gal.	Gasoline per hr. per water hp., gal.	Heat units supplied per hr. per water hp., B.t.u.
20	5.45	0.272	32.000
40	8.75	0.218	25,500
60	14.35	0.240	28.000

The curves (Fig. 7) show that the most economical working point for the engine is about 40 water-hp. output, at which point the least gasoline per horsepower is used and hence a horsepower is obtained with the least expenditure of heat units.

Assuming 50 per cent for the overall efficiency at the nozzle, which would seem to be a reasonable figure for efficiency of the pump and hose line, it is seen that the most economical conditions are obtained when the probable engine output is 80 hp., which is its rated power.

For 40-hp. output, 0.218 gal. of gasoline per hr. per hp. is used, which is equal to 1.74 pints of gasoline per hp-hr. An average value of 1 pint per hour per brake horsepower was obtained in 1912 on a 4-cylinder Seagrave motor similar in type. The value of 1.74 pints for the complete fire-engine unit

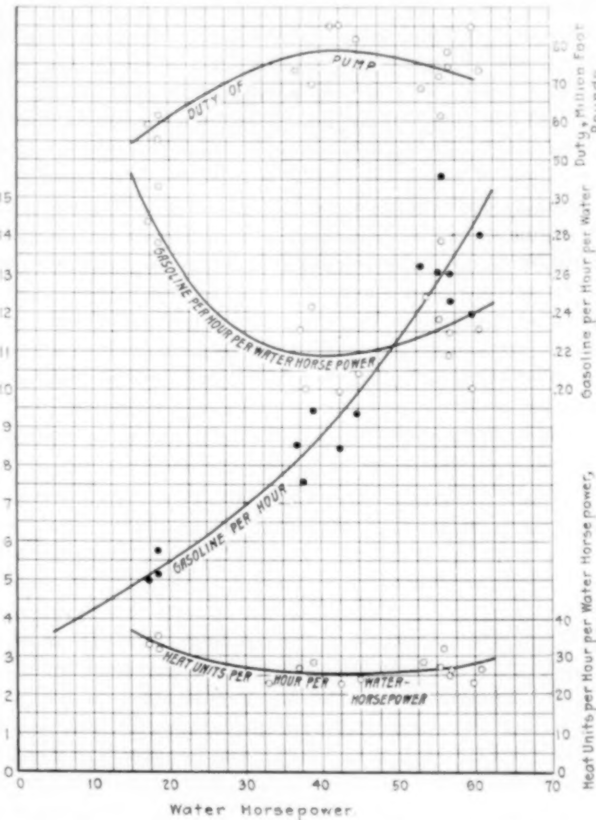

FIG. 7 PERFORMANCE CURVES FOR MOTOR FIRE ENGINE

seems a consistent figure when the frictional resistances of the pump and hose line are taken into account.

The advantage of the gasoline-driven engine is most noticeable when the comparison is made with the horse-drawn steamer, for the motor fire engine is able to reach the fire in half the time, is readily converted from the locomobile to the pumping engine, and is more easily and economically operated, with the expense of maintaining the proper number of horses entirely eliminated.

The paper closes with a comparison of the gasoline-driven engine and the horse-drawn steam fire-engine unit, leading to the conclusion that the motor fire engine is fully the equal of the steam fire engine in fire-stream capacity, and, except as to a slightly higher fuel cost at prevailing prices, is without doubt its superior in steadiness of pump action, as a time saver, in flexibility, in ease of operation, and in reduced cost of maintenance, especially when compared with the horse-drawn steamer.

THE DESIGN OF MOTOR-TRUCK ENGINES FOR LONG LIFE

BY JOHN YOUNGER, BUFFALO, N. Y.

Member of the Society

THE question of *life* in a motor-truck engine is naturally one which the engineer must compromise. An intense search after long life, to the exclusion of everything else, would result in a monstrosity which would be too heavy, too bulky, and too costly to run.

An approximate definition of *long life* would, therefore, be "that length of life which is something more than the average expected life, based on present-day knowledge and all-around conditions."

At the present day a life of 50,000 miles, without overhaul, would be considered long. This would correspond to a continuous run day and night for 12 months, at a speed of about 400 r.p.m., with no attention beyond oiling and fueling. The load will fluctuate between less than zero (as when in coasting downhill with clutch in, the chassis drives the engine) to the full power of which the engine is capable. The majority of the hauling will be done at an average of $\frac{1}{3}$ full engine power. An engine should be capable of at least five or six overhauls, or 300,000 miles, before renewal of the major parts.

This does not look at all severe to the casual glance of the power-house engineer, but when one considers that this power plant is operating under widely varying temperatures, power and speed conditions, and that its various axes are constantly changing relatively to the bed to which it is fastened, it will be seen that the problem of long life is not so simple as it looks.

Long life depends on three factors: (1) *Design*, (2) *Manufacturing excellence*, (3) *Operating conditions*.

DESIGN

This may be considered under headings such as: *a* bearing surfaces, *b* lubrication facilities, *c* materials used, *d* factors of safety, *e* general design and use of governor.

Explosion Pressure. All calculations should be based on full load, not on average load. This can be taken as an explosion pressure of 300 lb. per sq. in. on the piston with a 22 per cent compression volume.

Connecting Rod Bearings. The pressure per projected square inch should be about 700 lb. per sq. in., excluding area of oil leads and fillets at ends, or 1 sq. in. per 2.33 sq. in. of piston area.

Oil is conveniently introduced through a hole in the crankshaft, and the bearing may either be grooved with a slightly spiralling oil groove around the whole circumference, or a groove around the bottom half only, or a series of slots or labyrinth checks on the sides, or even no grooves at all. Any of these methods prevent ridge wearing on the crankshaft.

The bearing itself should be a thin shell of hard babbitt metal about 1/32 in. thick, backed up by a thick shell of hard bronze running on a case-hardened or otherwise hard surface. This gives the advantages of the babbitt as a bearing metal, and prevents it from pounding out. The bronze should be carefully turned and have peg holes in it to give perfect union between the two. The running clearance should be small, between 0.0015 in. and 0.0025 in., satisfying practically all truck engines. The split surfaces should be carefully fitted together to prevent rocking or cater-cornered work.

Gudgeon or Wrist-Pin Bushings. Owing to the slight oscillatory motion, pressures may be higher. Under the conditions of space and the necessity for keeping down the weight of reciprocating parts they may be as high as 1800 to 2000 lb. per sq. in. (or 1 sq. in. per 6 sq. in. of piston area).

Lubricating oil should be brought by a small tube (where pressure lubrication is used) direct to the bearing and allowed to ooze out. The majority of bushings are at present lubricated on what might be called the "chance" method,—the chances being, however, chiefly against. The metal should be a very hard chill cast phosphor bronze, running on a case-hardened steel surface.

Running clearances should be kept exceedingly low, 0.00025 in. being satisfactory. Very little tolerance should be allowed.

Pistons. The side bearing pressure is low, inasmuch as the facilities for lubrication are poor. Sixteen pounds per projected square inch is satisfactory. The piston should be as light as possible consistent with strength, so as to minimize the loads due to the reciprocating masses.

Three rings above the gudgeon pin are ample. They should be thick radially, and preferably of the concentric type, to even the pressure on the slots and prevent them wearing away. The S.A.E. standard for piston ring grooves is $G = \frac{1}{8}(0.01\,D^2) + 0.005$ where G is depth of groove, and D is nominal diameter of piston. A pressure of about 10 to 12 lb. per projected sq. in. is ample to keep the rings against the cylinder walls.

The piston should be made of a softish gray cast iron, running against a harder cylinder metal. The clearance should be great at the top to allow for expansion due to heat, being four times the piston diameter in thousandths above the top ring, and equal to it in thousandths on the skirt. This bearing surface is, as a rule, relieved around the gudgeon pin.

Cylinders. Cylinders should be of a hard, close-grained, high tensile strength cast iron. Its scleroscope hardness (though this is of doubtful value) will be found to be about 35. It should be made thick enough in the walls so that actually about 0.060 may be ground off the diameter to take care of wear, without causing weakness. For a 5-in. bore cylinder, 5/16-in. walls are sufficient.

Crankshaft. Three bearings—front, center and rear—are considered ample for a 4-cyl. truck engine. Consider the area of the connecting-rod bearing (big end) as 1, then the front and center bearings may have an area equal to 1 and the rear bearing 1.5. If splash or trough system of lubrication is used, the areas of the front and center bearings should be increased to about 1.2.

An approximate rule for the diameter of crankshafts in the usual sizes of motor-truck engines, is that the square of the cylinder bore shall be twice the cube of the crankpin. This gives a 2-in. shaft for a 4-in. bore engine, and about a 2 5/16-in. shaft for a 5-in. bore engine.

Running clearances lie between 0.0015 and 0.003 in., depending somewhat on the nature of the lubrication.

The bushings should be similarly constructed to those on the connecting-rod big ends, except that the spiral oil groove will probably be found preferable to give a continuous supply of oil to the connecting-rod bearings.

The material should preferably be about 0.40 to 0.50 per cent carbon steel, carefully heat-treated to give a tough, hard

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surface (scleroscope 36 to 40). The larger-diameter shafts should have a percentage of chromium and nickel to ensure better heat treatment and resistance to fatigue.

Low-carbon, case-hardening material is sometimes used, but the shaft has to be increased in diameter to compensate for the lessened resistance to fatigue.

Good-sized fillets, no machine-tool scratches and general smoothness of outline will materially help long life.

Camshafts. Camshafts should be made of a low-carbon steel, case-hardened on the wearing surfaces. The bushings should be of a good grade of phosphor bronze. Three bearings are ample for a 4-cyl. car. The diameter of the shafts should be from 1 in. to 1⅛ in., for the sake of smooth operation. The projected area of the bearings, front to rear, should be approximately 4 sq. in., 3 sq. in. and 2 sq. in., depending somewhat upon whether oil pumps or governors are driven from the camshaft.

Valves. The cams operating the valves should be so designed that just before the valve seats itself the velocity will be considerably diminished, allowing the last few thousandths of its travel to take place in a comparatively long time. This prevents the valve hammering on its seat. It does not interfere with the fuel economy or power, but gives quieter action.

A 45-deg. valve seat is advisable, as carbon will not be driven into the seat, but will more easily clear itself.

Valves containing a percentage of tungsten from 2 per cent upwards are most satisfactory as regards life and freedom from warpage. By scleroscoping them while hot, they will be found to hold a hardness of over 40. Cast iron remains about 30, while other steel and nickel alloys drop to 25 or lower. The tungsten valve has thus a reason for its long life.

Sundry Parts. The rest of the engine should be designed in proportion, such as wide faces on the timing gears and ample bearings for their spindles. The water pump should have ample bearing area, and if of the centrifugal type proper, provision should be made for the thrust of the blades.

Studs may be used for fastening down the cylinders, but they should have a length equal to twice their diameter screwed into the aluminum alloy, if such be used. A coarse thread is necessary, but for all purposes where aluminum is concerned, best results are obtained by the use of through bolts.

LUBRICATION

Considerable change has taken place in this in the last few years, although even yet all questions have not been settled, and cylinder lubrication is still somewhat on the hit-and-miss principle.

The method most in favor at present is to carry a supply of oil, about one gallon, in the crankcase of the engine, and pump it under a pressure of anything between 2 lb. and 20 lb. per sq. in. to a header pipe, from which issue leads to the crankshaft main bearings, and often the camshaft and timing-gear bearings. The surplus oil is by-passed by a regulating valve back to the crankcase. This oil and that which has done its work in the cylinders and crankshaft and various bearings drains down to the bottom of the case through a strainer and thence into the pump to renew the circuit.

When the oil gets dirty enough—or say every 300 miles or so, it ought to be thrown out and replaced with clean oil.

The system described works surprisingly well when it is considered that a certain amount of gasoline filters past the pistons and dilutes the oil—that some of the aqueous products of combustion also get past and help form an emulsion.

However, it can only be a matter of time before the adoption of some much better system of introducing fresh, clean oil to each bearing in predetermined quantities. Many oils are on the market and most of them are good.

Incidentally, as a point of design, it should be made easy for the driver to make sure that his oil is in good condition and of ample quantity.

MATERIALS AND FACTORS OF SAFETY

Naturally extreme consideration has not been given to weight, as has been in the case of aeroplane engines, when 2½ lb. per hp. has been reached. A fair weight for a motor-truck engine is nearer 20 lb. per hp. at a piston speed of 1000 ft. per min. Aluminum is used for the crankcase and its covers. Cast iron is used for the cylinders and pistons. 0.40 to 0.50 carbon steel is used for the crankshaft and connecting rods. Case-hardening steel is used for the camshafts, valve tappets and gudgeon pins.

In order to ensure the proper factor of safety being maintained, it is advisable to scleroscope each part for correctness of heat treatment or hardness. Forgings like connecting rods, camshafts, crankshafts, should be straightened before machining.

The general design should be such that extreme climatic conditions can be guarded against. Roads, for example, in winter time are exceptionally bad, causing a weaving of the bed of the engine as would correspond to one of the wheels being lifted 12 in. off the road. The engine should be mounted so that no stress due to this will come on the moving parts.

The engine power should be ample for its work. Too much gear work is detrimental to long life. The transmission reduction should be such that the great majority of road work should be done on high gear. For instance, the hilly city of Cincinnati requires a lower transmission ratio than would the comparatively level cities of Buffalo or Cleveland. This prevents the engine from working at maximum capacity for too much of the time.

Speed should be carefully limited. A maximum piston speed of 1000 ft. per min. is desirable, and drivers and purchasers should be educated to the economy of a governor which will enforce this. The governor should be so designed that it will not restrict the power, but should go in or out of action with a maximum 5 per cent variation in speed round the predetermined point.

MANUFACTURING EXCELLENCE

Too much stress cannot be laid on this. Poor workmanship cannot be tolerated in an internal-combustion engine. Cylinders should be ground to a maximum tolerance of 0.002 in., as should pistons, and in addition, a process of selection must be used which will ensure pistons on the high limit being put into cylinders of the low limit. The running clearances should not vary by more than 0.002 in.

Pistons, complete, should be weighed, the maximum variation in any one of a set being not more than ½ oz. Similarly, connecting rods should be weighed and balanced, the variation in one of a set being not more than ½ oz., with the ends varying also by as little.

Connecting-rod and crankshaft bearings should be selected so that a maximum variation from standard running clearance of 0.001 in. plus or minus should be adhered to.

There is some diversity of opinion as to the best way to finish these bearings, but the writer believes that a reamed

bearing is superior to the usual hand-scraped one. Reamers mounted on a rigid bar will true up crankshaft bearings in a way impossible by the hand reamer. Further, the surface left is as nearly round as possible, corresponding to that of the ground crankshaft. The personal element in hand-scraping is entirely eliminated.

Crankshafts should be ground smooth with a maximum variation of 0.0015 in. in diameter and 0.001 in. eccentric. Each shaft should be scleroscoped at every bearing. Similarly with the camshafts, pump and magneto-drive bushings and so forth, a uniformly high standard should be insisted on.

It follows naturally that rotating parts should be put in static and dynamic balance.

When the engine has been assembled, it should be placed on a stand and run in. Here again opinions differ, but the writer believes a run of at least 30 hours, at a piston speed of about 800 ft. per min., varying the load from zero at the start to practically maximum for one or two hours at the finish, is necessary.

Most of this test, if indeed not all, should be done with some kind of fuel, either gas or gasoline, to get the engine thoroughly warmed up. This will ease off the high spots, let the valves find their seats, and generally take the harshness out of the engine.

At the end of this run, the engine should be partially disassembled and valves reground, piston rings touched up, carbon cleaned and the engine carefully inspected for signs of wear or scoring flaws.

When reassembled, the engine is ready for work.

OPERATING CONDITIONS

One of the secrets of success in gasoline engines is oil and lots of it. After a comparatively short run, the oil (in the average system) is contaminated by gasoline and carbon. It should be drained out every 150 to 300 miles and replaced entirely by fresh oil.

The strainers leading to the pump should be kept clean and inspected frequently.

About once a month the whole engine should be cleansed by washing it out with kerosene, turning the crankshaft by hand and thoroughly draining the kerosene all out.

Screens should be provided on the air intake to the carburetor to prevent entrance of road dust as much as possible.

Gasoline should be cut down in the carburetor as much as possible, not only for the sake of economy in consumption, but also for the prevention of harmful effects by an overplus.

The point of ignition should be properly controlled, so that evils following an "advanced spark" will not result.

Drivers should change to a lower gear immediately there are signs of the engine laboring.

Drivers should be carefully selected and trained men. Good horse drivers make good truck drivers, as they are accustomed to giving care and attention to their "motive power."

A regular system of inspection should be carried out by a good mechanic to detect any signs of trouble developing.

It is understood that hilly country or heavy roads will materially add to the work the engine has to do, and that the life will be proportionately shortened and inspection and overhauling will have to be done more frequently.

The amount of crude petroleum delivered to refineries and consumers in February 1917 from the Oklahoma-Kansas field was 4,546,461 barrels, from the Appalachian field 2,105,744 barrels, and from the Lima-Indiana field, 1,421,520 barrels.

THE RELATION OF PORT AREA TO THE POWER OF GAS ENGINES AND ITS INFLUENCE ON REGULATION

By J. R. Du Priest, Moscow, Idaho

Member of the Society

The early forms of gas engines were of comparatively small power, and as engines of this size do not usually require close speed regulation, the "hit-and-miss" system of governing was applied quite successfully. As the machine was improved in design it became more reliable in service and was gradually applied to other classes of service in competition with steam engines and under conditions requiring better speed regulation.

This resulted in multi-cylinder engines to give more uniform turning moment, and "cut-off" and "throttling" governors to give power on every cycle. These improvements have enabled the modern gas engine to give excellent and reliable service, and to have a field almost as broad as the steam engine. However, designers are still striving to improve the machine in every way possible, adapting it to cheaper grades of fuel, improving its speed regulation, simplifying its mechanism, and making it more reliable and economical, so that its field of service may be still further increased.

The object of this paper is to present a method of determining the port area required for any fractional load on a throttling gas engine operating on the four-stroke cycle, and to suggest a means of admitting the fuel so as to get the same degree of speed regulation throughout the full range of load.

DISCUSSION OF PROBLEM

The function of a constant-speed governor on an engine is to control the speed within certain limits (depending on the class of service for which the machine is designed), while the load varies anywhere within the capacity of the engine.

In all types of governors dependence is placed on the change in speed of the governor to effect regulation, and when this governor is driven from the main engine, the speed of the engine must change before the governor can act on the valve gear and exert any influence over the energy supply.

If the load on the engine increases, the order of changes in the governing system is as follows:

a Speed of the engine decreases

b Speed of the governor is reduced

c The change in the position of the governor, due to the change in speed, shifts the valve gear and supplies more energy to the engine to enable it to carry the increased load, and at the proper speed

d The speed of the engine increases, due to the increased supply of energy, hence the speed of the governor increases, and the cycle above described is repeated in the reverse order. This action tends to produce a "hunting" effect on the valve gear and governor until the energy supply is properly proportioned to the existing load.

Apparently, the most desirable results would be obtained if the governor were so connected to the valve gear that equal movements of the governor collar would correspond to equal changes in load.

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The energy supplied to the gas engine is in the form of a combustible mixture of air and gas, the quality of which may vary considerably, also the head causing flow through the ports varies with every change in load, if it is a throttling engine.

In the four-stroke-cycle gas engine, the fuel mixture is made to flow into the cylinder by lowering the pressure in the cylinder below that of the atmosphere during the suction stroke, thus creating a difference of pressure sufficient to force in the charge.

The absolute pressure in the cylinder depends on the quantity of mixture entering the cylinder during the suction stroke. The amount of charge necessary in the cylinder depends on the load the engine is carrying, and therefore it is evident that a different amount is required for every change in load. Hence the absolute pressure in the cylinder during the suction stroke will be different for every different load, and the resulting pressure head causing the mixture to flow into the cylinder will be different.

This point can be most easily understood by neglecting temperature changes occurring during the suction stroke and assuming that the volumetric efficiency is merely a function of

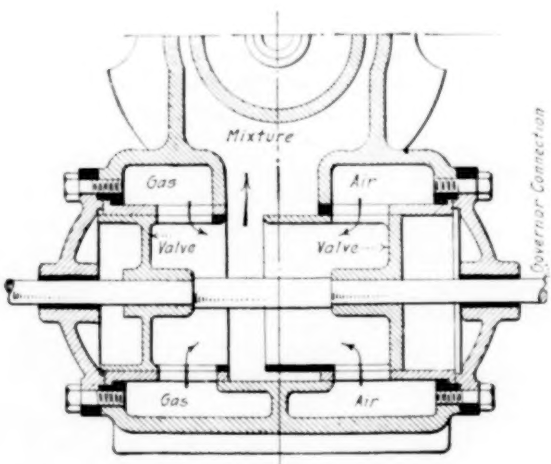


Fig. 1 Section Through Throttle Valve of a Horizontal Double-Acting Gas Engine

the difference between suction and atmospheric pressures. Since a light load calls for a small charge, it must correspond to a low volumetric efficiency. The low volumetric efficiency is always accompanied by a low suction pressure, due to the throttling at the valve, and therefore we have the peculiar condition that the greatest difference in pressure is available to cause flow when the least amount of mixture is required.

The result of this change in absolute pressure in the cylinder is such that when an engine is operating at, say, three-quarter load, with an apparent volumetric efficiency of about 67 per cent, and a change in load occurs which demands a volumetric efficiency of 77 per cent, it will require a much larger port area to give this increase of 10 per cent in volumetric efficiency at the heavy load than it would if the increase were from 30 per cent to 40 per cent. The reason being that, in the first case, the head causing flow through the ports will be about 3.5 lb. per sq. in., while in the second case it will be about 7.5 lb. per sq. in.

On account of the greater head causing the charge to flow into the cylinder at light loads, it requires a very small change in port area for a considerable change in load. Therefore, any system of connecting up the governor to the throttle valve which gives equal changes in port area for equal changes in the governor speed, will make the regulation of the engine very sensitive at light loads and too slow at heavy loads.

Data and Results from Test

The test described below was made to find out as near as possible (1) the conditions under which the fuel mixture enters a gas-engine cylinder, and (2) the relation of port area to horsepower and its influence on the regulation of the engine.

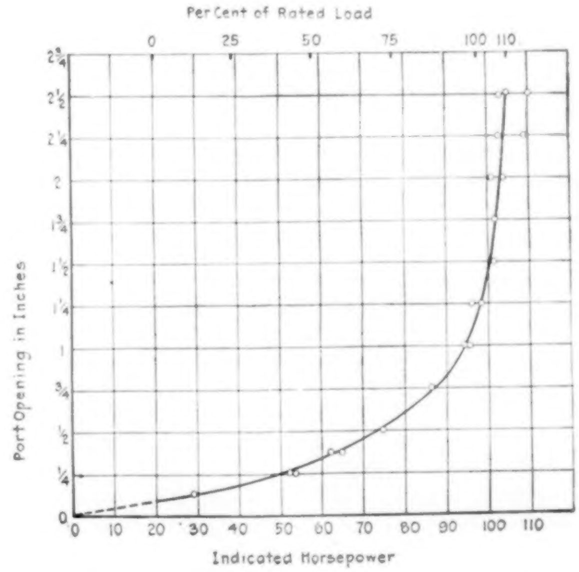


Fig. 2 Relation Between Indicated Horsepower and Port Opening

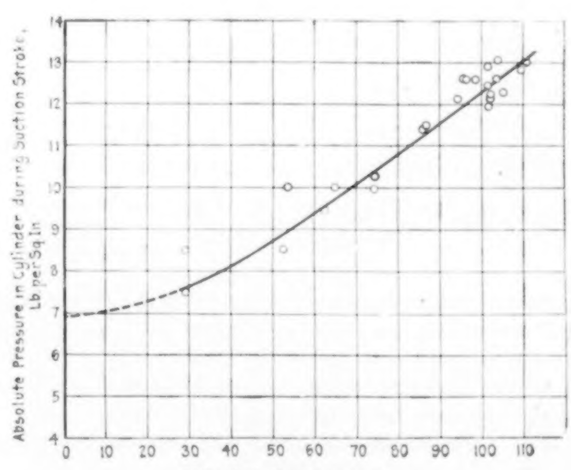


Fig. 3 Relation Between Indicated Horsepower and Pressure in Cylinder During Suction Stroke

Method of Making the Test. The engine tested was a $16\frac{1}{2}$ x 24-in. horizontal double-acting tandem engine operating on natural gas. The test was made in the following manner: The throttle valve on the head end of No. 1 cylinder was disconnected from the governor and operated by hand, while the other three valves, under the control of the governor, took care of the load on the engine. The throttle valve shown in Fig. 1 is cylindrical, with six rectangular ports cut around the periphery which mate with similar ports cut in a surrounding sleeve when the valve rotates. The throttle valve is made to

open and close in unison with the poppet inlet valve and is moved longitudinally by the governor to effect regulation. The travel of the valve was 2.5 in., and fifteen different settings were made, varying from closed to wide open. Two sets of indicator cards were taken for each setting, one for indicated horsepower and the other for suction, two or more cards for each set being taken for every position of the valve. From data obtained from these cards, curves were plotted, respectively, as follows:

Indicated horsepower
- against port opening
- against absolute pressure in cylinder during suction stroke
- against apparent volumetric efficiency

Port opening
- against apparent volumetric efficiency
- against absolute pressure in cylinder during suction stroke

Apparent volumetric efficiency
- against absolute pressure in cylinder during suction stroke.

If the machine friction is assumed constant for all loads, which is very nearly true, the delivered horsepower (d.hp.)

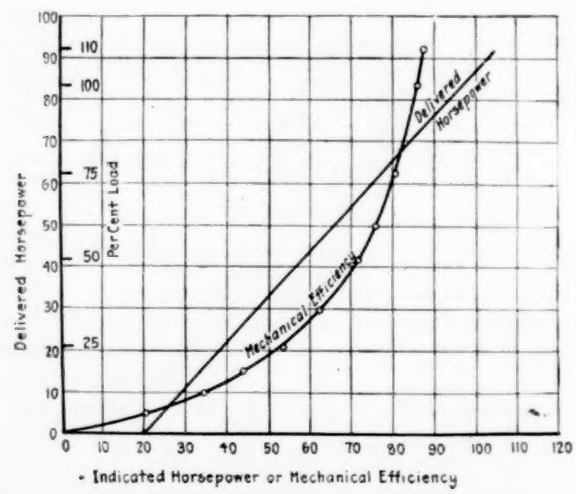


Fig. 4 Relation Between Delivered Horsepower and Mechanical Efficiency

for any load can be determined from the indicated horsepower by subtracting the loss due to the suction stroke, as measured by the suction card, and the loss due to the machine friction.

The d.hp. for several valves of i.hp. was found in the above manner, and from the results the mechanical efficiency was calculated. The values for i.hp., d.hp. and mechanical efficiency are given in the curves in Fig. 4.

Fig. 5 shows the relation between port area and d.hp. The data for this curve were obtained as follows: Delivered horsepower corresponding to any given i.hp. was taken from Fig. 4. The port openings as plotted in Fig. 2 are linear dimensions, the ports being rectangular in shape, 2½ in. long by 1½ in. wide.

The mixing valve was rigidly connected to the inlet valve and opened and closed in unison with it. The cam arrangement was designed to give a valve-opening curve approximating the sine curve, with the maximum port width (H) 1½ in.

The effective port area under these conditions is L x H x 0.637. The port opening or length L of port for full load is 1.15 in., as shown in Fig. 2. Therefore, the port area is 1.15 x 1.5 x 0.637 = 1.1 sq. in. for each port and for six ports it is 6.6 sq. in. Port areas for one-quarter, one-half, three-quarter and full load were found in this way and plotted against delivered horsepower, giving Fig. 5.

From Fig. 5 it can be seen that when the engine is operating near the rated-load point, it takes a large change in port area to effect a small change in the work developed by the machine, while at light loads a very small change in port area makes considerable change in the work done by the engine. The reason for this condition can be found by studying Fig. 3, from which it is seen that when the engine is operating at, say, full load, the absolute pressure in the cylinder during the suction stroke is high, being 12.1 lb. per sq. in. absolute or 2.1 lb. per sq. in. below the pressure of the atmosphere, while at one-quarter load the absolute pressure in the cylinder is 8 lb. per sq. in. or 6.2 lb. per sq. in. below the pressure of the atmosphere. The amount the cylinder pressure is below atmosphere pressure is the head available to force the charge into the cylinder, hence the peculiar conditions noted above exist, that when the engine is operating at full load and requiring a large amount of charge, the pressure head to produce flow into the cylinder is small, and when the engine is operating at light load and requires a small amount of charge, a much larger pressure head is available to produce flow through the ports.

From the above discussion and Fig. 5, it is evident that port area does not increase directly as the delivered horsepower increases, therefore, to get the same degree of regulation throughout the full range of load, some compensating device should be introduced between the governor and the throttle valve to take care of this condition. From Fig. 5 and the characteristic curve of the governor to be used, a mechanism can be designed which will give equal changes in load for equal movements of governor collar. This would seem to be a more desirable condition for good operation.

Theoretical Development—Outline of Method

It has been found from tests that the total heat consumption of an engine follows a straight line very closely when plotted against delivered horsepower, and by assuming a reasonable value for the B.t.u. per d.hp-hr. for two points, say full load and half load, the total-heat curve can be drawn. From this curve with the heating value of the gas and the ratio of air to gas known, the cubic feet of mixture required for any fractional load can be determined. This amount of mixture, which must enter the cylinder, occupies a certain volume under atmospheric conditions. At the end of the suction stroke it occupies the greater part of the piston displacement but is under some lower pressure p_2, which can be determined by the relation $p_1v_1^n = p_2v_2^n$, providing the proper value of n be known.

From analyzing a great many low-spring indicator cards taken from throttling engines, it has been found that the absolute pressure in the cylinder during the suction stroke remains nearly constant throughout the greater part of the stroke, except for light loads. For the purpose of this discussion, it can be assumed to remain constant without serious error and will be the pressure p_2 of the charge when occupying the new volume as found from the equation above. The difference between the absolute pressure in the cylinder during the suction stroke and the pressure outside the cylinder is the head causing the charge to flow through the ports.

Knowing the amount of mixture required and the head producing flow, the area of the port necessary to pass the given amount of charge can be determined. In the above manner,

the amount of mixture required for any given load and the port area necessary to pass this charge can be determined, thus giving a relation between power and port area.

[The author here proceeds to apply the method outlined to the engine tested, which ran at 180 r.p.m. on natural gas of

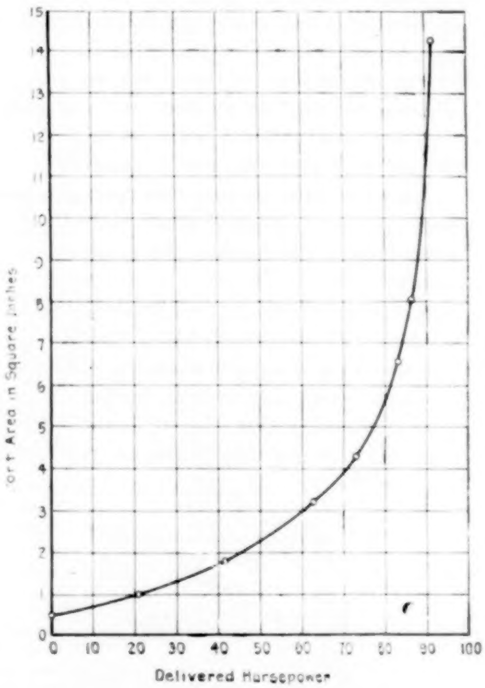


FIG. 5 RELATION BETWEEN DELIVERED HORSEPOWER AND PORT AREA

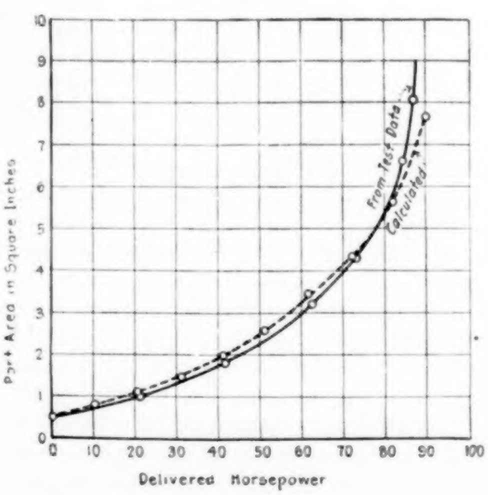


FIG. 6 RELATION BETWEEN DELIVERED HORSEPOWER AND PORT AREA FROM TEST AND CALCULATIONS

about 950 B.t.u. per cu. ft. He employs a value of 0.85 for n in the equation $p_1v_1^n = p_2v_2^n$, and shows in an appendix why this value is chosen.

He also derives an empirical equation for the port area necessary to pass a given amount of charge, which gives results agreeing closely with those obtained from test data. See Fig. 6.]

CONCLUSIONS

The work described has been done to find out as nearly as possible the conditions under which the charge enters the cylinder of a throttling gas engine, and to suggest a method of supplying the required amount of charge for any load that will tend to make the engine regulate with the same degree of sensitiveness throughout the full range of load. In Fig. 6 there are two curves showing the relation between delivered horsepower (d.hp.) and port area; one is based on test data and the other is plotted from calculated data for the same engine. From these curves and the characteristic curve of the governor to be used, the relation between the travel of the governor collar and port area can be determined and a governing mechanism designed which will give equal changes in load for equal movements of the governor collar. Another way of obtaining the same result would be to shape the ports in such a manner that equal changes in governor-collar travel would give equal movements to the valve, but at the same time give the proper port area for equal changes in power delivered. It is possible that for other fuels and types of engines the constants used in working out the above problem may differ slightly, but it is believed that the method can be applied to any case with satisfactory results.

Metals for Coinage. War conditions, which have been responsible for the replacement of gold coinage by paper money, have also had their effect on the metals used for coins of the smaller denominations. Aluminum money has been used by the Chambers of Commerce of several French towns, and Austria, following the example of Germany, has adopted iron money. The problem of protecting the iron disks from rust has been solved by superimposing a slight layer of zinc. The disks, with some zinc powder, are placed in a vessel and heated for a certain time at a temperature somewhat below the melting point of zinc. A surface is thus formed which not only preserves the pieces from rust, but also enables the die to be impressed without cracking the surface of the metal. The zinc-plated iron money hardly differs in aspect or weight from that formed of nickel.—*Ironmonger,* March 24, 1917.

X-Rays and Metals. Some authorities hold the view that X-rays are destined to play an important part in research of steel and other metals, especially in investigations on the crystalline structure. The perfect crystal has a definite internal geometrical form and a definite atomic symmetry, but the latter is beyond the range of the microscope. The more powerful X-rays may, however, enable the metallurgist to determine the atomic structure of his metals. Students of the new method predict that it will throw light on some phases in metallurgy of which nothing is known at present. The commercial value of the researches remains, of course, to be proved; but the progress of the work is being followed with deep interest in various countries. Professor Bragg, a pioneer in this work, in a recent address on the subject at Sheffield, England, remarked that chemistry told the metallurgist what were the constituents of his metals, but thought X-rays were going to help him to find and study the atoms of the substances, and the actual arrangement of these and the distances at which they lay apart were of considerable importance, but had hitherto been beyond human vision. The X-rays had made it possible to see the architecture of a number of substances. Iron and steel presented difficulties, but there was a good prospect of getting useful information about them before long. The work was going ahead in the United States, and he had received from American physicists particulars of interesting results obtained in respect to iron and steel crystals. —*Ironmonger,* March 24, 1917.

MISCELLANEOUS PAPERS

One session of the Spring Meeting will be devoted to the discussion of miscellaneous papers upon the subjects of tests of uniflow steam traction engines, relation of efficiency to capacity in the boiler room, radiation error in measuring temperature of gases, development of scientific methods of management in a manufacturing plant, and disk-wheel stress determination. All of these papers are printed below.

TESTS OF UNIFLOW STEAM TRACTION ENGINES

By F. W. MARQUIS, COLUMBUS, O.

Member of the Society

At first thought it seems strange to find refinements such as the uniflow cylinder and the superheater in connection with traction engines; but when it is remembered that traction engines are used extensively in certain districts (notably the northwestern part of the United States) where fuel is very expensive and water has to be hauled many miles, the reason for taking advantage of every means for reducing coal and water consumption becomes apparent.

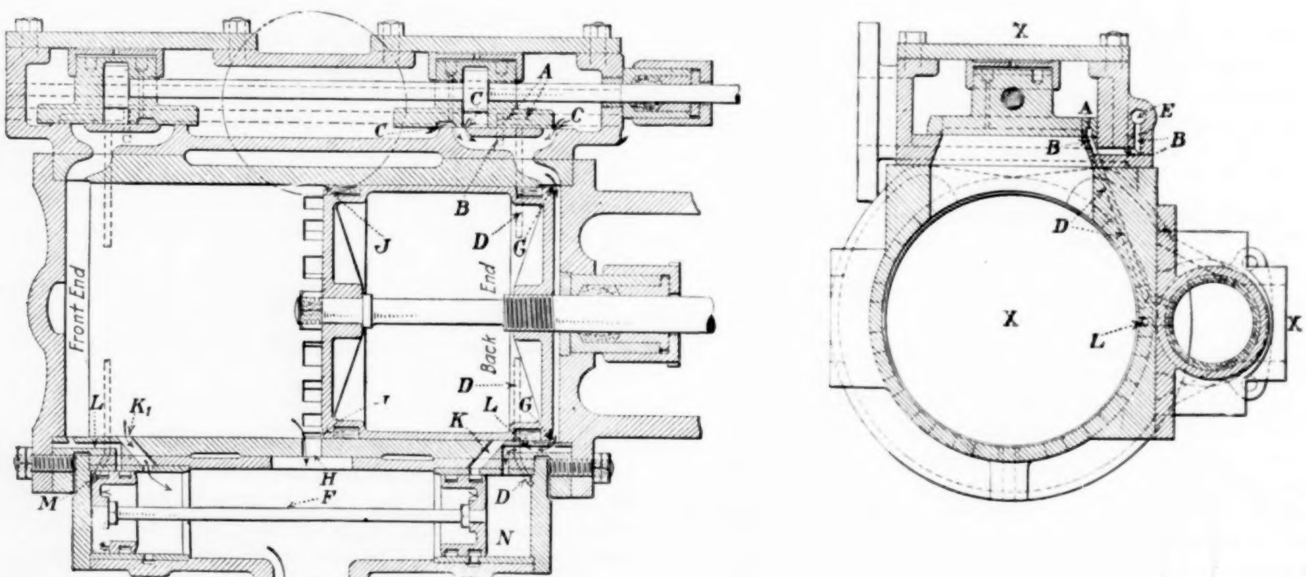
It was, therefore, with a great deal of interest, in the spring of 1915 and again in the spring of 1916, that tests of Baker uniflow traction engines were undertaken as thesis work by members of the senior class of the Mechanical Engineering Department of The Ohio State University.

The engine tested in 1916 was almost identical with that tested in 1915, except that in 1916 the boiler was supplied with a smokebox-type superheater. The piston displacement of the engine tested in 1916 was 8½ per cent larger than that of the engine tested in 1915 and the water heating surface of the boiler 24½ per cent larger. Both machines were made by the A. D. Baker Company, of Swanton, Ohio, and in accordance with their standard designs, except for the uniflow cylinder and the superheater, which were then in process of development.

The principal dimensions of both engines are given in Table 1. Besides the uniflow cylinder and the superheater, the feature of particular interest is the valve gear, which deserves special attention and will later be described.

Figs. 1 and 2 show cross-sections through the cylinder and valves. There are triple-ported admission valves, and an auxiliary exhaust valve which causes the compression to begin late in the stroke.

The operation of the valves can best be explained by following their movement as the piston moves through one stroke. Suppose the piston to be moving towards the right and nearing the end of its stroke; that is, a little to the left of its position in Fig. 1. The admission valves (top of figure) will then be a little to the right of the position shown, and moving towards



Figs. 1 and 2 Baker Uniflow Cylinder and Valves

the left. The auxiliary exhaust valve F (bottom of figure) will be at the extreme right end of its travel, and stationary.

When the edge J of the piston uncovers the ports at the center of the cylinder, exhaust commences. About the same time the cavity A in the admission valve uncovers the port at the end of passage B and allows live steam to flow from E (Fig. 2), through passage B, cavity A and passage D into chamber N at the end of auxiliary exhaust valve F. This causes valve F to move to the extreme left of its travel, closing the auxiliary exhaust port K and opening the auxiliary exhaust port K_1. Exhaust is then taking place both through the main exhaust ports and through auxiliary exhaust port K_1. An instant after the auxiliary exhaust valve moves and just before the piston reaches the end of its stroke, admission takes place through the three ports C.

As the piston starts on the return stroke towards the left, exhaust takes place through the main exhaust ports until, early in the return stroke, they are covered by the piston. The

For presentation at the Spring Meeting, Cincinnati, Ohio, May 21 to 24, 1917, of The American Society of Mechanical Engineers. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained by members gratis upon application. All papers are subject to revision.

TABLE 1 PRINCIPAL DIMENSIONS OF BAKER UNIFLOW TRACTION ENGINES

	Engine used in 1915	Engine used in 1916
ENGINE		
Nominal horsepower	16	18
Nominal r.p.m.	240	240
	In.	In.
Diameter of cylinder	8¾	9¼
Stroke	10¼	10
Diameter of piston rod	1¼	1½
Diameter of flywheel	36	38
Face of flywheel	10	11
Diameter of crankshaft	3	3¼
Length of crankshaft	55½	61½
Diameter of crankpin	2¼	2¼
BOILER		
Number of tubes	40	54
	In.	In.
Outside diameter of barrel	29	32
Length of firebox	36	40
Width of firebox	22¼	25
Diameter of tubes	2	2
Length of tubes	78	72
	Sq. Ft.	Sq. Ft.
Grate area	5.56	6.94
Firebox heating surface	23.6	29.1
Tube heating surface	123.2	153.6
Total water heating surface	146.8	182.7
Superheater heating surface	....	47

steam still continues to exhaust through auxiliary exhaust port K_1 until the piston covers this port, late in the stroke, when compression starts. Meanwhile live steam has been admitted on the other side of the piston until the admission valve has returned and cut-off has occurred. After cut-off and during expansion, the live steam in chamber N, at the head of the auxiliary exhaust valve, is free to expand through passage L and do work on the piston. This passage L enters the auxiliary exhaust valve chamber at such a point that when the valve is thrown some steam is trapped between it and the end of the valve chamber, thus cushioning it and preventing pounding.

The admission valves are driven by a Baker valve gear, which is very similar to the Baker locomotive gear. It is a single-eccentric variable cut-off and reversing gear which maintains equal leads for all cut-offs and in both directions of running. The complete paper illustrates and describes the gear.

The boiler used in the 1916 tests was fitted with a smokebox-type superheater, consisting of a vertical cast-iron header, into which tubes are inserted, as shown in Fig. 3. Steam enters through pipe A, Fig. 4, which leads from the steam dome and passes to the front section of the header. It then passes back through the ½-in. pipes and forward through the 1½-in. pipes into the back section of the header. Thence it passes through B to the steam chest.

METHOD OF PROCEDURE IN TESTING

The tests were conducted in the Mechanical Engineering Laboratory of The Ohio State University and in general the methods recommended in the A.S.M.E. Power Test Code were followed. All coal fired was weighed, sampled, analyzed and the calorific value determined. The feed water was weighed and correction made for injector overflow and other wastes. The quality of steam was taken with a Barrus throttling calorimeter, the sampling pipe being located in the path of the steam as it left the steam dome. Smokebox temperatures were determined with a thermocouple and the smokebox gases were sampled continuously, and analyzed with an Orsat apparatus. Indicated and brake horsepower and revolutions per minute were all carefully determined. All instruments were calibrated and corrections applied where necessary.

The tests were run with the throttle valve wide open, and in general it was attempted to maintain the speed constant at 250 r.p.m. During the preliminary running preceding each test the brake load was adjusted so that the desired speed was obtained

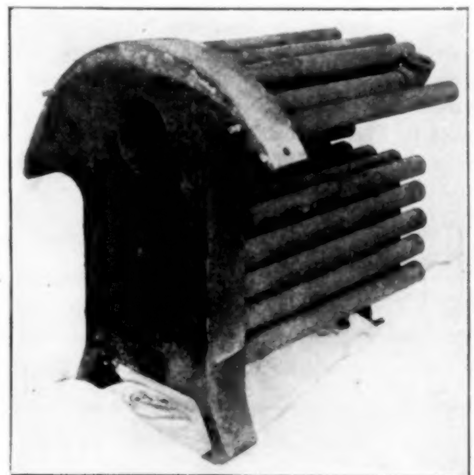


FIG. 3 SUPERHEATER REMOVED FROM BOILER

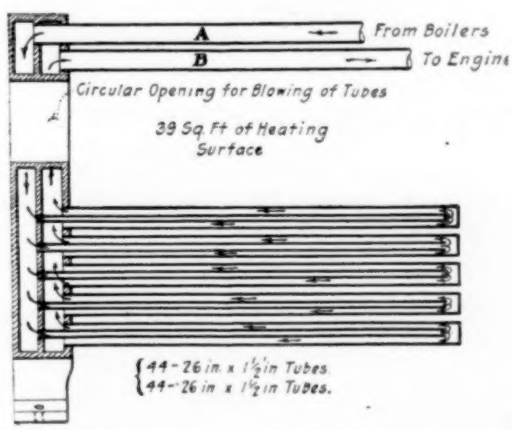


FIG. 4 DIAGRAM OF SUPERHEATER

when the throttle valve was wide open. During each run all conditions were maintained as constant as possible.

First Series. The 1915 series consisted of 17 tests with various boiler pressures ranging from 125 lb. gage to 175 lb. gage, and various cut-offs ranging from 6 to 49 per cent. Saturated steam was used throughout this series, and the approximate speed was 250 r.p.m. in all tests.

Second Series. The 1916 series consisted of 17 tests, 13 at 180 lb. gage and 4 at 160 lb. gage. Nine of the former were with superheated steam, and 4 with saturated steam. Superheated steam was used for the four latter tests. The cut-off in this series varied from 16 to 75 per cent. The approximate speed was 240 r.p.m., with the exception of three short runs

made with variable speed to secure data concerning the relation between speed and power.

RESULTS

The results having to do with engine performance, with the boiler, and with the overall performance are tabulated in the paper. Many of these results are also presented graphically in Figs. 5, 6 and 7.

In Fig. 8 are two sample sets of indicator diagrams, one with a rather early and the other with a much later cut-off. They show a remarkable lack of wire-drawing during admission, and sharp cut-off for a slide-valve engine running at such a high speed (250 r.p.m.). The drop in the early part of the expansion line of the diagrams with an early cut-off, and that in the admission line of the diagrams with the later cut-off, is caused by the steam flowing into the auxiliary exhaust-valve chamber at the instant the piston uncovers the port leading to this chamber.

Reference to Fig. 5 shows that the highest steam consumption was just under 29 lb., which occurred at 125 lb. boiler

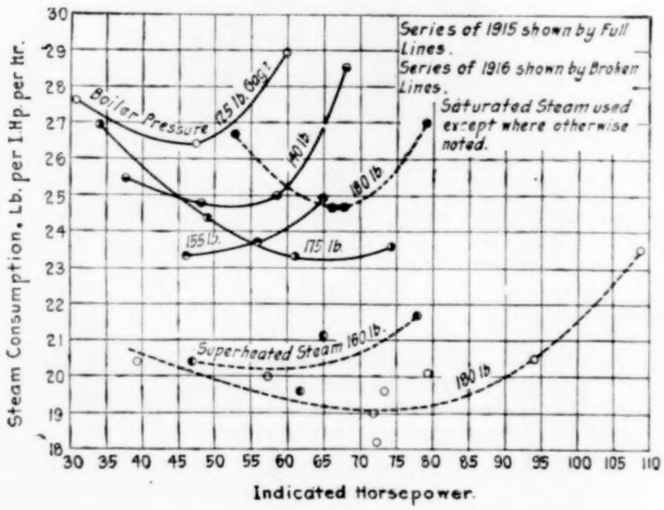


FIG. 5 CURVES SHOWING RELATION BETWEEN STEAM CONSUMPTION AND INDICATED HORSEPOWER

pressure with saturated steam and at approximately 60 i.hp. The lowest was 18.2 lb. per i.hp-hr., in the series of 1916, with 180 lb. boiler pressure and 118 deg. superheat, at about 72 i.hp. Reference to the curve shows, however, that this point was abnormally low.

It seems reasonable to assume that the engine should be rated at approximately the point of best economy. On this basis the rating when operating under 125 lb. boiler pressure would be 45 hp. Tests were run from about 30 to about 60 i.hp. or from about 60 per cent to 130 per cent of this rated load, and over this range the variation in steam consumption was from approximately 29 to 26½, or only about 2½ lb.

It is interesting to note that the maximum power obtained was 108.7 i.hp. (102.8 b.hp.) which was obtained with 180 lb. boiler pressure and with 181 deg. fahr. superheat, and with a steam consumption of only 23.5 lb. per i.hp. per hour (24.5 lb. per b.hp. per hour). This becomes particularly interesting when it is remembered that the cylinder diameter and stroke of this engine were only 9¼ in. and 10 in. respectively.

The curves in Fig. 6 show the relation between steam consumption and boiler pressure. As the boiler pressure increases, not only does the steam consumption decrease, but also the power at any cut-off, and the power at which the lowest steam consumption occurs increases. It will be noticed that, with the exception of one point on this curve, the power of minimum steam consumption increases as the boiler pressure increases.

The curves of Fig. 7 show the relation between the pounds of coal used per brake horsepower per hour and the brake horsepower developed.

As a matter of interest from a comparative point of view,

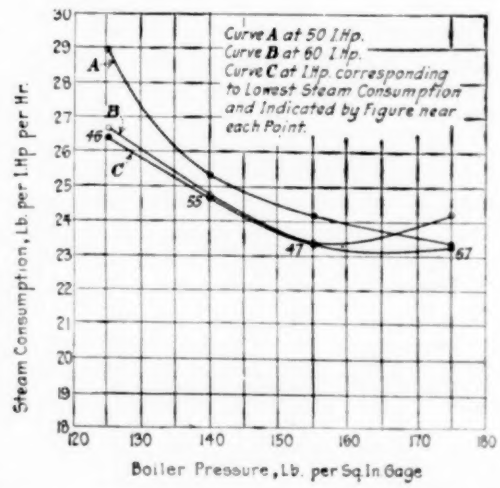


FIG. 6 CURVES SHOWING RELATION BETWEEN STEAM CONSUMPTION AND BOILER PRESSURE, SERIES OF 1915

the steam-consumption curves of a number of the ordinary counterflow type of steam engines, both simple and compound, non-condensing and condensing, have been plotted on the same sheet with certain of the steam-consumption curves of the Baker uniflow engine. These curves are given in Fig. 9. Information concerning each of the engines whose steam-consumption curve is given in this figure will be found below.

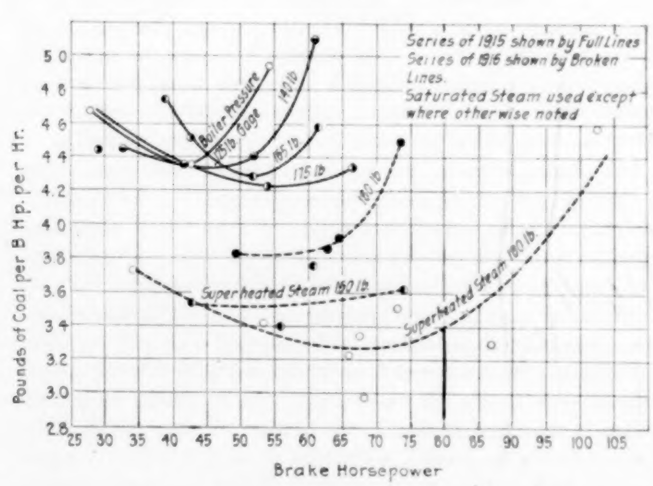


FIG. 7 CURVES SHOWING RELATION BETWEEN POUNDS OF COAL PER BRAKE HORSEPOWER PER HOUR AND BRAKE HORSEPOWER

Curve *A*. Simple, slide-valve engine, cylinder 8 in. by 12 in., initial steam pressure 130 lb. gage, non-condensing, and at 200 r.p.m.

Curve *B*. Simple, slide-valve engine, cylinder 9 in. by 12 in., initial steam pressure 140 lb. gage, non-condensing, and at 290 r.p.m.

Curve *C*. Simple, slide-valve engine, cylinder 15 in. by 14 in., initial steam pressure 115 lb. gage, non-condensing, and at 225 r.p.m.

Curve *D*. Same engine as in case of curve *C*, but operating condensing.

Curve *E*. Cross-compound, slide-valve engine, cylinders 7 in. and 13 in. by 10 in., initial steam pressure 150 lb. gage, non-condensing, and at 310 r.p.m.

Curve *F*. Same engine as in case of curve *E*, but operating condensing.

Curve *H*. Tandem compound, slide-valve engine, cylinders $8\frac{1}{4}$ in. and $13\frac{1}{4}$ in. by 12 in., initial steam pressure 115 lb. gage, condensing, and at 280 r.p.m.

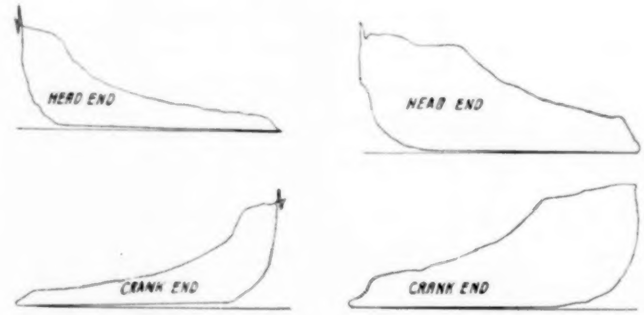
Curve *G*. Simple uniflow engine, cylinder $8\frac{3}{4}$ in. by $10\frac{1}{4}$ in., initial steam pressure 125 lb. gage, non-condensing, and at 250 r.p.m.

Curve *I*. Same engine as in case of curve *G*, but with 175 lb. gage boiler pressure.

Curve *K*. Simple uniflow engine, cylinder $9\frac{1}{4}$ in. by 10 in., initial steam pressure 180 lb. gage, superheat approximately 130 deg. fahr. non-condensing, and at approximately 240 r.p.m.

It will be seen that the uniflow-engine curves selected are those representing the poorest and the best results obtained with saturated steam, and the best results obtained with superheated steam.

A study of this set of curves (Fig. 9) shows that the poorest results obtained with the uniflow engine, namely, those of curve *G*, obtained with saturated steam at 125 lb. pressure, are better than the best results obtained with any of the simple engines, even when operating condensing, and almost the same as those obtained with the compound non-condensing engine shown by curve *E*. The steam consumption of the uniflow engine at 175 lb. pressure with saturated steam running non-condensing is lower than that obtained with the compound non-condensing



Run No.1. Series of 1915. 125 lb Boiler Pressure, Saturated Steam

Run No.7. Series of 1916. 180 lb Boiler Pressure, Superheated Steam

FIG. 8 SAMPLE INDICATOR DIAGRAMS

engine at 150 lb. pressure shown by curve *E*. Also the steam consumption of the uniflow engine with 180 lb. steam pressure and 130 deg. superheat was lower than that of the compound condensing engine with 150 lb. steam pressure shown by curve *F*.

Thus it is seen that on the basis of the results of the tests and of the information presented by Fig. 9, which is thought to represent fairly the average practice for small simple and compound engines of the older or counterflow type, the simple uniflow engine operating with saturated steam and non-condensing is able to surpass in economy of steam consumption the compound counterflow engine when operating under similar conditions. Also that the simple uniflow engine operating non-condensing but with superheated steam will have approximately the same, or slightly less, steam consumption than the compound counterflow engine operating condensing but with saturated steam.

On the bases of these conclusions, it seems probable that the simple uniflow engine will prove a serious competitor of the compound counterflow type, since it is not only more economi-

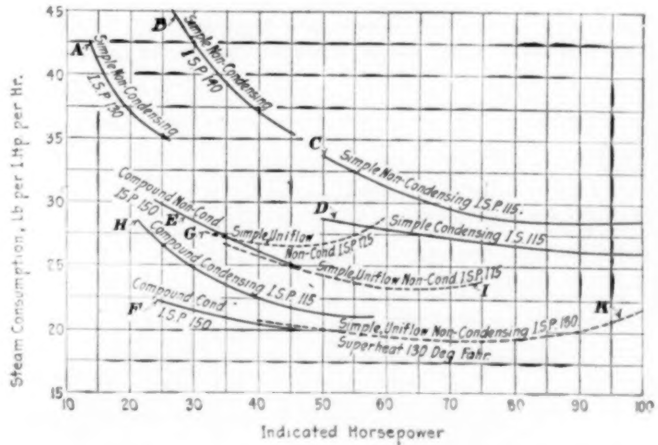


FIG. 9 RELATIVE STEAM CONSUMPTION OF BAKER UNIFLOW ENGINES AND COUNTER-FLOW ENGINES

cal in its use of steam, but also simpler in construction, and probably on that account lower in first cost.

RELATION OF EFFICIENCY TO CAPACITY IN THE BOILER ROOM

BY VICTOR B. PHILLIPS,[1] CLEVELAND, OHIO

THERE are two ways in which the cost of producing steam may be reduced. They are efficient operation and the attainment of high capacity from equipment. Table 1 gives the typical figures for the various elements of cost entering into the production of steam, according to the accounts of the Cleveland Railway Company for the year 1914. The numbers shown in parentheses refer to the accounting system prescribed by the Interstate Commerce Commission. This table shows the predominating importance of fuel and fixed charges, and hence the importance of both efficiency and capacity and their interrelation.

To the end of establishing the operating conditions giving maximum efficiency for a wide range of capacities, the writer has made an extensive series of tests for the Cleveland Railway Company. The tests were conducted under widely different operating conditions in order to bring out clearly the importance of the several variables and also to throw light on questions of design. In Table 2 is a condensed summary of the data obtained, together with some notes as to procedure.

GENERAL DESCRIPTION OF TESTS

Equipment (see Fig. 1). Taylor six-retort stoker with extension grate. Babcock & Wilcox boiler, 5120 sq. ft. heating surface.

[1] Cleveland Railway Company.

For presentation at the Spring Meeting, Cincinnati, Ohio, May 21 to 24, 1917, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The paper is here printed in abstract form, and pamphlet copies of the complete paper may be obtained by members gratis upon aplication. All papers are subject to revision.

Duration. Eight hours, preceded by preliminary run under test conditions; setting under heat for several days before tests, except for Tests 7 and 8 which therefore show small discrepancies when referred to boiler-operation chart. Readings taken every 15 min.

Personnel. In addition to regular operating fireman and helpers, personnel included six men all of whom had become thoroughly familiar with their duties through previous tests.

TABLE 1 COST FACTORS IN STEAM PRODUCTION

CLEVELAND RAILWAY COMPANY

		Per cent of total cost	
1 (53)	Fuel	50.1	50.1
2 (54)	Water	3.4	....
3 (55 & 56)	Oil and miscellaneous supplies	0.4	....
4 (46 & 47-A & B)	Maintenance	6.4	....
5 (52-A)	Employees	9.6	9.6
6 (50)	Depreciation, 4½ per cent on investment	11.3	11.3
To these must be added interest, taxes and insurance, 7½ per cent on investment		18.8	18.8
	Total cost of producing steam	100.0	
	Fuel and fixed charges	.....	89.8

Coal and Water. Both items were weighed on newly calibrated scales. Coal sample taken from every wheelbarrow and placed in covered receptacle.

Air Supply. Air delivered to furnace from fan was measured by pitot tubes placed in air ducts and preceded by baffles to create parallel flow; permanently located pitot tubes were calibrated by complete traverses in two directions through the pipe and results checked with an anemometer and by the calorimetric method. Pressure and draft gages checked.

Temperatures. Obtained by thermo-electric pyrometers, checked by manufacturer before and after tests.

Gas Analysis. Conducted by chemist. Continuous samples taken during consecutive half-hour periods. Sampling tube inserted at top of first pass; lined with hard glass tubing and open at end only; moved in and out so as to get representative sample. Analysis made with Orsat apparatus.

Regulation of Fire. Fuel bed was kept uniform and constant in thickness, by very close and frequent observation on the part of three different men, all experienced firemen.

Ash Analysis. All ash was spread out and crushed to about 1½ in. on a large concrete floor and dried before weighing. The sample for analysis was taken by dividing the ash, when evenly spread out, into a large number of squares, and then moving away alternate squares until a comparatively small sample for grinding was obtained. During this reduction process the ash was continually mixed by turning it over. The samples were analyzed for moisture, combustible and in some cases for sulphur or volatile constituent.

SCOPE OF PAPER

This paper proposes for discussion the systematic treatment of the steam boiler in relation to the two fundamental variables —efficiency and capacity. The efficiency which obtains at a given capacity depends upon the interrelation of a large number of variable factors of operation. It is essential that these factors be systematically conceived, and that in a given case some idea of their relative importance be formed. Recent stoker developments to the end of greater flexibility have introduced a large number of adjustments over which intelligent control must be exercised. This merely goes to illustrate the

TABLE 2 SUMMARY OF TEST DATA

CLEVELAND RAILWAY COMPANY

Test No.	1	2	3	4	5	6	7	8	9
1 Fuel bed thickness	Thin			Medium			Thick		
2 Horsepower output of boiler (steam pressure 150 lb. gage)	452	661	895	500	736	923	504	718	902
3 Dry coal per hour, lb	1,695	2,450	3,700	1,960	3,100	4,000	2,690	3,600	4,320
4 Coal analysis									
a B.t.u.	12,631	12,718	12,744	12,795	12,888	12,944	12,802	12,802	12,672
b sulphur	4.00	4.00	4.00	4.00	4.00	4.00	4.16	4.16	3.93
c ash	13.2	12.4	12.6	12.4	11.8	11.6	12.5	12.5	13.2
5 Air pressure under tuyeres (inches of water)	0.46	1.33	2.63	0.55	1.68	2.79	1.03	2.41	3.27
6 Draft in combustion chamber (inches of water)	0.22	0.25	0.25	0.25	0.27	0.41	0.15	0.15	0.45
7 Pounds air per hour by meter	20,100	30,900	42,600	15,700	30,200	46,500	20,900	37,200	43,500
8 Average of air by meter and by analysis	25,200	32,000	38,500	17,850	30,300	40,250	21,900	34,250	42,250
9 Temperature of air, deg. fahr.	66	66	68	66	69	70	79	80	72
10 Temperature in last pass	532	644	734	500	659	771	509	596	728
11 Sensible heat to stack, per cent [1]	14.5	17.0	14.6	8.4	12.1	14.7	7.6	10.4	13.7
12 Combustible in ash, per cent loss [2]	5.1	4.0	7.6	4.6	10.0	7.0	17.3	17.3	20.0
13 CO loss [3]	0.4	0.8	10.9	6.6	11.2	13.9	14.8	11.4	....
14 Latent heat of steam in flue gas	3.5	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.7
15 Overall efficiency	70.7	71.2	63.5	66.9	61.7	59.7	49.0	52.1	54.8
16 Furnace efficiency	85.2	88.2	78.0	75.3	73.8	74.4	56.5	62.5	68.5
17 Output of furnace, boiler hp.	544	820	1,100	563	880	1,150	583	862	1,127

[1] Flue gas per pound of coal, taken from items 3 and 8 to which is added 0.8 pound for gasified coal.

[2] One sample for Tests 7 and 8.

[3] The CO analyses, especially for the overload tests (Nos. 3, 6 and 9), were probably somewhat in error due to taking of sample at top of first pass where gases were not thoroughly mixed. During Test 9 both the oxygen and CO content of the flue gas taken at this same point were high. There was also a marked amount of incandescent matter in the flue gas. It is therefore probable that considerable combustion of CO occurred in the second and last passes. This is indicated by the fact that the items of the heat balance for this Test 9 added up to a little more than 100 per cent.

necessity of less prejudice and more rational procedure in boiler-room design and operation.

In what follows, a classification of the variables of operation will be outlined, and a system of testing discussed, whereby their interrelation may be established. The results of the tests already quoted, which were made in accordance with this system, will be used by way of illustration. All mathematical treatment and detail of procedure are listed in an appendix. It should be pointed out at the outset that the test data used are necessarily limited, and in some respects incomplete. Yet perhaps they will serve as a concrete basis or example in outlining the method of treatment.

ELEMENTS OF BOILER UNIT AND BASIC FACTORS WHICH GOVERN ITS PERFORMANCE

The steam-boiler unit is considered here in relation to each of its two elements, the *furnace* or heat liberator and the *boiler* or heat absorber.

The furnace is a means whereby the chemical energy of coal or other fuel is transformed into sensible-heat energy. The function of the furnace is chemical reaction between the combustible fuel and the oxygen of air. As such, it is governed

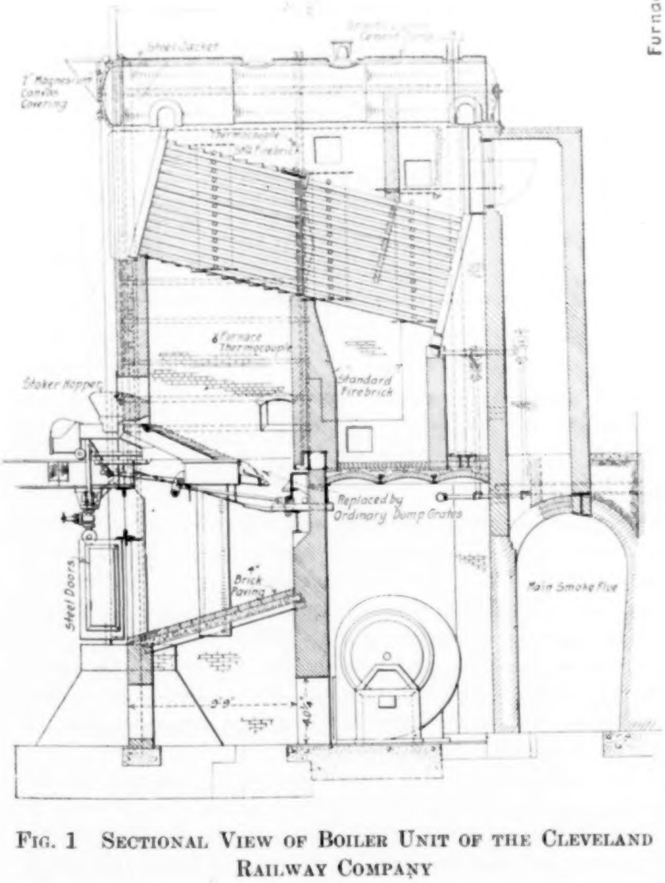


Fig. 1 Sectional View of Boiler Unit of the Cleveland Railway Company

by the three factors, (1) amount of air, (2) degree of air mixture and (3) time. These three factors together govern the rate of combustion, the completeness of combustion and the resultant temperature of combustion; in a word, they completely determine the nature of combustion.

The boiler is a means whereby the heat liberated in the furnace is absorbed and transferred to the water. Its function is heat transmission and it is governed by the laws expressing the several modes of heat transmission,—conduction, convection and radiation. It is evident that the factors which govern combustion likewise govern very largely the heat transmission of the boiler, by the regulation of temperature and amounts of gas. Hence, it follows that in the end the performance of the entire boiler unit may be expressed in terms of a number of factors over which the fireman either does or should be able to exercise proper control.

Before proceeding with the separate discussions of the two elements of the boiler unit, it is necessary to define clearly the lines of separation of the furnace and the boiler. It is desirable so to define furnace efficiency and boiler efficiency that

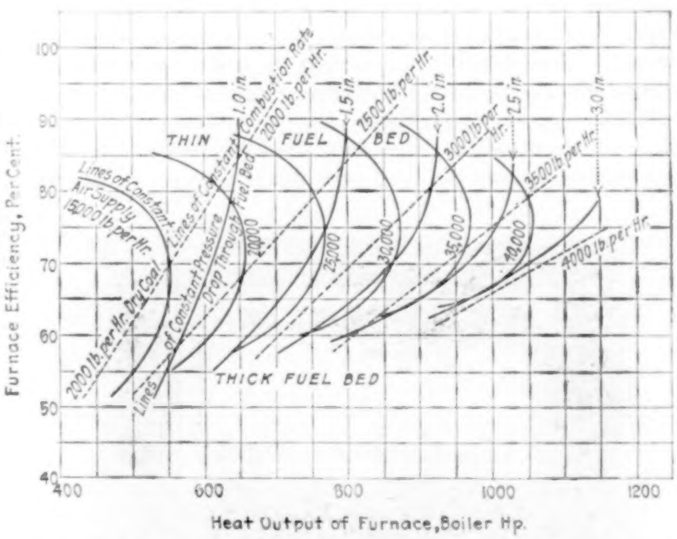


Fig. 2 Furnace-Operation Chart. Taylor Six-retort Stoker with Extension Grate

their product will be the overall efficiency of the unit. To this end boiler efficiency is taken as the ratio of heat absorbed to the heat available for absorption, *i.e.,*

$$E_B = \frac{\text{heat in steam}}{\text{heat in steam and sensible heat in flue gas}}$$

Furnace efficiency is defined as the ratio of heat available for absorption by the boiler to the heat in the coal, *i.e.,*

$$E_F = \frac{\text{heat in steam and sensible heat in flue gas}}{\text{heat in coal}}$$

and

$$E\,(\text{overall efficiency}) = E_F \times E_B$$

This method arbitrarily charges against the furnace all losses through the setting, such as radiation and leakage. Most of these losses do occur in the setting around the furnace and so this arbitrary classification is reasonable. It also charges against the furnace the loss in latent heat in the vapor of the discharged flue gases.

THE FURNACE

The ideal furnace for any form of fuel is one in which the three factors of combustion mentioned above,—amount and admixture of air, and time for completion of combustion, may be regulated independently. This furnace would have wide limits of efficient operation wherein it would be possible to attain at once both efficiency and capacity. Unfortunately the present status of the art, particularly in regard to coal-burning furnaces, falls far below this ideal.

The most important methods of firing coal employ the

chain grate and the underfeed and overfeed gravity stokers. In each of these cases the time of transit of coal decreases with increase of load and is not subject to independent regulation, and also it is impossible to regulate independently the amount and admixture of air. The factors of air supply are controlled together by the amount of draft or pressure and by the condition of the fuel bed. These several inflexibilities are inherent in the present status of the art. They are serious disadvantages which may be reduced, however, by introducing in other ways a large degree of flexibility.

Since regulation of the time element by regulation of grate surface seems to be impracticable, the problem of furnace operation becomes simply the *problem of the air supply,* not merely over the fuel bed as a whole, but in its several parts separately. That flexibility of air supply will to some extent compensate for inflexibility in time of transit, may be illustrated by any of the underfeed gravity stokers. The grate areas of these stokers have been proportioned to give the proper time element for rated capacity.

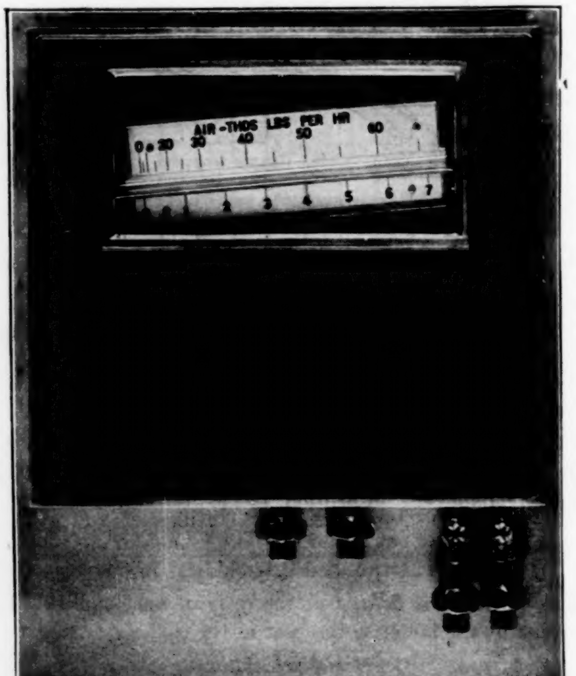


Fig. 3 Air Meter

For example, take the case of the Taylor stoker used in the equipment of the Cleveland Railway Company's plant which the writer tested. When the capacity is increased, the air supply on the lower or coking grates cannot be increased enough to burn the coal as fast as it is received from the upper grates. The result is a piling up of coke and ash on the dump and extension grates causing not only a large loss from carbon monoxide and coke to the ash pit, but perhaps serious clinker difficulties. A variable grate surface would eliminate this trouble. It could, however, be largely mitigated by flexible and independent air control for this section of the fuel bed. This is discussed further in the Appendix.

FUNDAMENTAL FACTORS OF OPERATION OF THE FURNACE

The operating variables of the furnace are simply the variables governing air supply. They are (1) thickness of fuel bed, (2) condition of fuel bed, and (3) pressure drop through fuel bed. These variables may be regulated differently in different parts of the furnace, but they are in all events the fundamental factors involved. They determine efficiency and capacity. In order to operate a furnace properly, the interrelations between efficiency and capacity and the foregoing variables must be established.

The validity of this principle has not been generally realized. Instruments for the indication of certain variables have been extensively used. Yet, either the number of instruments or the amount of rational interpretation has been insufficient. It is only in very special and limited cases that efficiency or capacity is indicated by a single variable factor such as carbon dioxide, or flue temperature.

Having defined the fundamental factors of operation, it now remains to select means of indicating these quantities to the fireman. The means of indication necessarily vary for different types of stokers and furnaces. With a chain grate the thickness of fuel bed may be readily measured and adjusted, and its condition is for the most part uniform. The draft in the combustion chamber constitutes the pressure drop through the fuel bed. Thus the chain grate readily lends itself to this system, and it is a simple matter to determine by tests

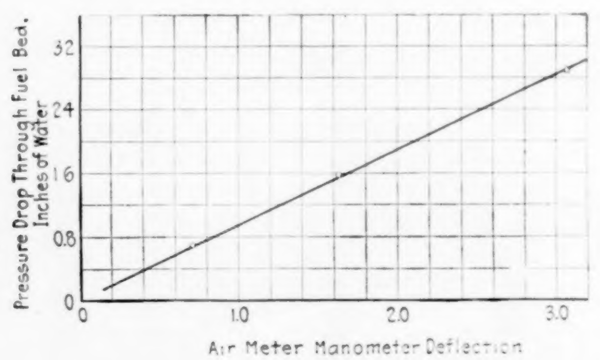


Fig. 4 Relation Between Pressure Drop Through Fuel Bed and Air Meter Manometer Deflection. Fuel Bed of Constant Thickness

the relation of furnace efficiency and capacity to the operating variables. In fact, the limits of expedient and efficient operation with the chain grate are not only narrow, but readily apparent. This is a salient feature of this type of stoker. On the other hand, the forced-draft underfeed stoker is not by any means so simple, and here intelligent control is not only effective but essential. In this case the thickness of fuel bed cannot be *directly* measured nor is its uniformity so much a matter of course.

The point of primary importance is the amount of air pushed through the fuel bed and the intimacy with which it is mixed with the volatile matter forming in the lower layers of green coal and the coke of the upper layers. Roughly speaking, this intimacy increases with the resistance to air flow. It is the condition and thickness of the fuel bed that determines both the amount and admixture of air. The pressure necessary to force up a certain quantity of air is both a simple and an effective indication of the mean condition and thickness of the fuel bed; in other words, an air-pressure gage and an air meter indicate the thickness of bed. In stokers of sufficient size to warrant the use of two air ducts, it is necessary to duplicate the air-measuring apparatus. By proper arrangement of the means of indication it now becomes

possible to gage the uniformity of the fuel bed by comparing the air indications to the two halves. Thus all the conditions governing air supply may be readily measured, and indicated to the fireman. In order that he may make proper use of these indications they must be related to the objects sought—efficiency and capacity.

As an illustration of the actual interrelating of the above indications, there is presented in Fig. 2 a chart showing graphically the results of the tests applying to the furnace.

It may be seen that this chart is a graphical representation of the principles outlined above. It shows how furnace capacity and efficiency are functions of extremely simple variables, and how any two of the variables fix conditions of operation. An analogy is a steam chart on which any two conditions, such as heat and pressure, or quality and temperature, determine a point from which the other corresponding conditions may be found. The chart brings out in conclusive manner the essential importance of the variables selected at the beginning of the discussion—thickness of fuel bed and pressure drop. So far as the furnace as a heat liberator is concerned, it establishes the conditions of maximum efficiency for each and every load.

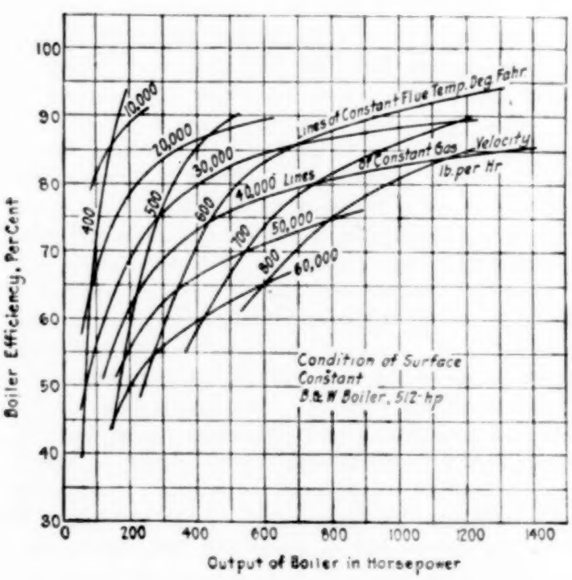


FIG. 5 THE BOILER AS A HEAT ABSORBER. BOILER-OPERATION CHART SHOWING INTERRELATION OF VARIABLES

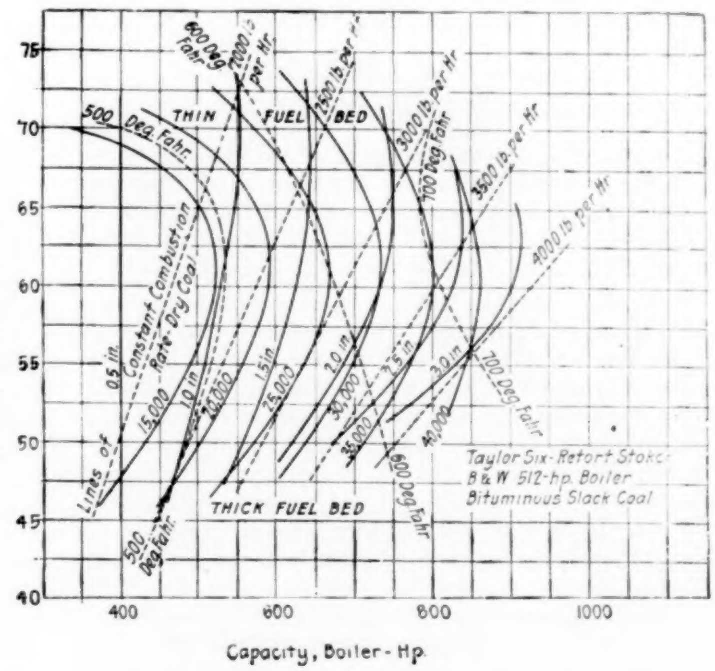


FIG. 6 OPERATIVE CHART, COMBINED BOILER UNIT

MEASUREMENT OF AIR SUPPLY

Of the instruments used by the writer in obtaining the results presented here, the apparatus for directly measuring the air supply, Fig. 3, merits perhaps a brief statement. It is quite possible to employ the pitot tube with close accuracy for measuring the air supply of forced-draft furnaces, and even where conditions are extremely unfavorable to obtain at least excellent relative results. The manometer used in connection with the pitot tube may be placed at a distance from the air duct, along with the other boiler instruments, without impairing its accuracy. When two manometers are necessary because of two air ducts the sloping tubes may be placed side by side and readings taken from a single scale. The only time that the liquid levels will not be side by side will be when the fuel bed is not uniform, a condition requiring immediate attention from the fireman. For example, a hole will cause a very marked difference in the two manometer levels.

Another principle may be employed in connection with the form of air meter just described. The pitot-tube manometers show deflections increasing as the square of the air velocities. Similarly, neglecting the relatively small amount of gas formed from the burning coal, the pressure drop through the fuel bed varies as the square of the air velocities. Hence, as is shown in Fig. 4, the relation between this pressure drop and the manometer deflection is a direct proportion. Utilizing this principle, another manometer tube[1] may be placed beside the other tubes for the measurement of pressure drop. By using liquids of the proper relative densities, or by introducing variation in the sectional area of the manometer, the levels can be set to move up and down together for the proper thickness of fuel bed; and a ready indication of amount of variation from the prescribed thickness is available. This last function is valuable in plants having short peak loads. The fireman may gage the amount by which he is building up his fuel preparatory to the short overload. Thus a single instrument has been made to indicate all the fundamental conditions of combustion—amount of air, pressure drop through the fuel bed, and thickness and uniformity of fuel bed.

THE BOILER

The performance of the boiler as an apparatus for absorbing heat is here analyzed in the complete paper along the same general lines as the furnace. The furnace produces heat which is available for absorption in the form of radiant energy and of hot gases, that is, the heat generated in the incandescent fuel bed is transmitted to the boiler surfaces by radiation and by convection. It is then transmitted from

[1] Not shown in Fig. 3 but exactly similar to the two tubes shown.

the outer to the inner surfaces and to the water by conduction. The boiler employs, therefore, all three modes of heat transmission, and the variables of operation are those determining the effectiveness of each of these three modes. These variables are (1) temperature, (2) condition of surfaces and (3) gas velocity. Temperature is the predominant variable; it affects all three modes of transfer, in each case a temperature gradient being necessary. The condition of surfaces affects principally two modes of transmission, convection and conduction; while gas velocity affects simply convection.

BOILER-OPERATION CHART

Relations derived between the heat absorbed by the boiler, and the two variables,—*flue temperature* and *gas velocity,* are combined into a single chart, Fig. 5, which is the boiler-operation chart, and corresponds to the furnace-operation chart previously shown. It expresses the relation of efficiency and capacity to the fundamental factors—temperature and velocity of the gases.

COMBINED BOILER-UNIT-OPERATION CHART

Following this separate treatment of the two elements of the boiler unit—the furnace as a heat liberator and the boiler as a heat absorber—the paper here combines the results of the two analyses. As an example of such procedure there is presented in Fig. 6 the combined boiler-unit-operation chart.

It is evident that the factors governing furnace operation also determine the variables of boiler operation. The gas passing through the boiler is simply the air of combustion plus the weight of gasified coal (corrected, if necessary, for infiltration). The temperatures in the boiler are governed by the combustion conditions in the furnace. Hence, overall boiler efficiency and capacity are to be expressed simply in terms of the furnace variables—*thickness of fuel bed* and *pressure drop through fuel bed.* In the case presented here fuel bed thickness is indicated by weight of air and pressure drop, and these values therefore become the criteria of combined performance. The function of flue temperature is simply a check upon the condition of the heating surfaces. The combustion rate curves shown on the chart are of value only in assisting in the proper maintenance of fuel bed. However, this information is not necessary, since an insufficient fuel supply shortly disturbs the prescribed relation between air and pressure drop. Reference to the data shows very little variation in the character of the coal used in the tests, the results of which have been here presented.

The combined boiler-unit-operation chart brings out the essential importance of the variable factors which have been selected as determining performance. It supplies the information whereby the firemen may operate with maximum efficiency for each different load. It establishes the relation between efficiency and economy wherewith the economic policy of the boiler room may rationally be planned. Lastly, a study of the chart and of the reasons for its characteristics becomes a sound basis for improvement in design.

In conclusion the writer states clearly his position, which is not an unqualified acceptance of any single system of analysis, but rather the acceptance of the *principle* of systematic analysis. He believes there is no engineering problem which is immune to this principle.

An appendix describes the procedure for convection tests and for the determination of radiation heat, and discusses the furnace and stoker characteristics.

RADIATION ERROR IN MEASURING TEMPERATURE OF GASES

BY HENRY KREISINGER, PITTSBURGH, PA.

Member of the Society

AND

J. F. BARKLEY,[1] PITTSBURGH, PA.

Of the errors entering into the determination of the average temperature of a stream of hot gases surrounded by colder or hotter surfaces, the radiation error is the most serious one and the most difficult to correct. Ordinary temperature measurements made with commercial devices under such conditions are from 5 to 25 per cent in error. If the surrounding surfaces are cooler than the gases, the temperatures indicated by the measuring instrument will be too low; or if the surrounding surfaces are hotter, as is the case in regenerating furnaces, they will be too high.

The object of this paper is to show primarily how large the radiation error may become under certain conditions of temperature measurements, and that judgment must be used in interpreting the accuracy and the value of temperature readings.

The radiation error is due to the fact that, to a large extent, gases are permeable to radiation. When a temperature-measuring instrument is immersed in a stream of hot gases surrounded by cooler surfaces, it absorbs heat from the gases by convection and its temperature rises. As soon as its temperature exceeds that of the surrounding surfaces, heat passes by radiation from the instrument to these surfaces through the intervening gases. Thus the instrument receives heat from the hot gases by convection, and gives off heat by radiation to the surrounding colder surfaces. The temperature of the instrument continues to rise with a decreasing rate, until the quantity of heat it gives off is equal to the quantity of heat it receives; the temperature then remains constant. Under these equilibrium conditions the temperature of the instrument is between that of the stream of gases and that of the surrounding surfaces; in other words, it is lower than the temperature of the gases which it is intended to measure.

In a similar way, when the instrument is inserted in a stream of gases surrounded by surfaces hotter than the gases, and when equilibrium conditions obtain, the temperature of the instrument is somewhere between that of the surrounding surfaces and that of the stream of gases; in other words, it is higher than the temperature of the gases which the instrument is supposed to measure. The difference between the temperature of the gases and that indicated by the instrument is the radiation error.

The magnitude of the radiation error depends on: (1) the size of the part of the instrument exposed to the gases and the radiation, and (2) the difference between the temperature of the gases and the temperature of the surrounding surfaces. The smaller the exposed part of the measuring instrument, the smaller the radiation error; also, the smaller the difference between the temperature of gases and the temperature of the surrounding surfaces the smaller the radiation error. In the measurement of the temperature of gases only the first-named factor can be controlled. The second factor is fixed by the kind of apparatus and its operation.

[1] Junior Electrical Engineer, U. S. Bureau of Mines.

For presentation at the Spring Meeting, Cincinnati, Ohio, May 1917, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The paper is here printed in abstract form and advance copies of the complete paper may be obtained by members gratis upon application. All papers are subject to revision.

Of the instruments used in the measurement of temperature of gases, the thermocouple lends itself the best to the reduction of its size. It can be made so small that the radiation error is negligible for practical purposes. The correct temperature would be indicated only by a thermocouple having an exposed hot junction made of wires of zero diameter, which, of course, is a physical impossibility.

The effect of the size of thermocouples is shown in Fig. 1, which gives two sets of temperature measurements of the gases passing through a Babcock and Wilcox boiler fired with natural gas. One of these sets of measurements was taken with thermocouples having the hot junction made of wires 0.008 in. in diameter and the other made of tubes about 0.500 in. in diameter. This large couple is about the size of commercial instruments used for such purposes. Several thermocouples of each size were made and clamped together in pairs, each pair containing a large couple and a small couple, with their hot junctions about $1\frac{1}{2}$ in. apart. These pairs were placed at different points along the path of gases, indicated by the small circles and designated by the letters *A, B, C, D, E, F* and *G* in Fig. 2. All the couples were connected to a central switch and read in rapid succession with a portable potentiometer. While the readings were taken the furnace conditions were kept uniform, which was a comparatively easy task with the gas firing.

In Fig. 1 the abscissæ are the approximate lengths of the paths of gases, measured from the position of the first pair of couples *A*. The full heavy curve connects the readings obtained with the large couples, and the full light curve the readings obtained with the small couple. The dotted curve above the full curves gives the probable true temperature of the gases, obtained by extrapolation from later curves. The curve near the bottom of the figure (drawn with dashes) gives the approximate velocity of the gases computed from the volume of gas burned, the chemical analysis of the products of combustion and the true temperature of the gases. The small black circle at the upper left hand corner gives the furnace temperature as measured with the Wanner optical pyrometer sighted through one of the gas burners, as shown in Fig. 2.

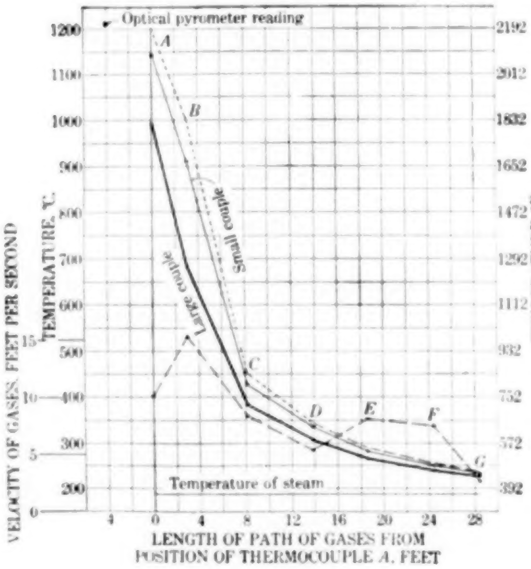


Fig. 1

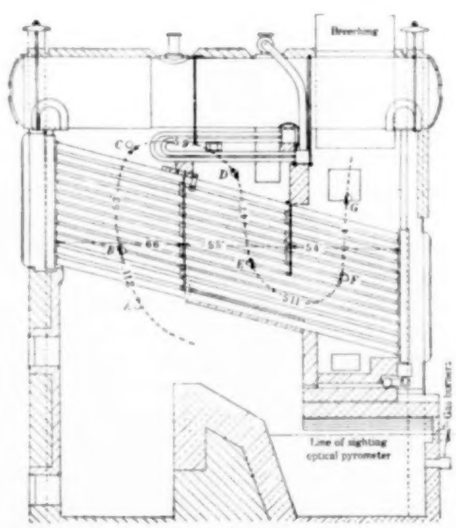


Fig. 2

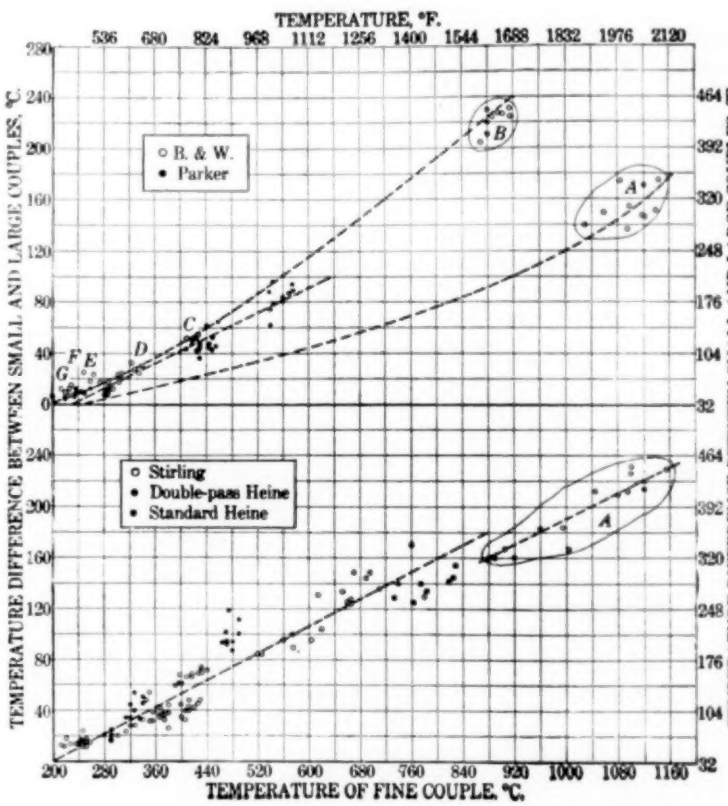


Fig. 3

Fig. 1 Temperature of Gases as They Pass Through Babcock and Wilcox Boiler

Fig. 2 Setting of Gas-Fired Babcock and Wilcox Boiler in Which the Measurements Were Made. Total Heating Surface, 3400 Sq. Ft.; Steam Pressure, 165 Lb. by Gage.

Fig. 3 Effect of Temperature of Gases on Radiation Error in Various Types of Boilers

The two full curves of Fig. 1 indicate that the small couples consistently showed temperatures considerably higher than the large couples, although the small couples themselves read somewhat too low. The difference between the readings of the two couples is nearly proportional to the difference between

the true temperature of the gases and the temperature of the surrounding boiler surfaces, which was about 50 deg. higher than the temperature of steam in the boiler. The large couple at *B* shows a radiation error of about 575 deg. fahr., whereas the small couple at the same place indicates an error of only 150 deg. fahr.

Fig. 3 shows how much lower the large couples read than the small ones when the couples were placed in the boiler settings of five of the common types of water-tube boilers. The readings were plotted on two charts to avoid crowding the points. With the exception of the groups marked *A*, all the readings were obtained with the thermocouples placed among the tubes, or in other places where they were almost totally exposed to the heating surfaces of the boilers.

The group *A* of the Babcock and Wilcox boiler was obtained with the thermocouple placed in position *A*, Fig. 2. In this position the thermocouples were exposed partly to the boiler tubes and partly to the brick walls and the clay-tile furnace roof, which latter surfaces were much hotter than the boiler tubes. Therefore the thermocouples did not lose as much heat by radiation as those couples which were completely surrounded by the boiler tubes, and their radiation error was smaller.

Group *A* of the lower half of Fig. 3 was obtained with the couples placed about 1 ft. above the arch and 1 ft. from the front nest of tubes in a setting of a standard Stirling boiler. They were therefore exposed partly to the boiler tubes and to some extent also to the hot brickwork of the furnace. Therefore the radiation error of these couples was somewhat smaller than the radiation error of the other couples completely surrounded by the boiler tubes.

Dotted curves were drawn through the groups of points representing readings of couples having nearly the same exposure to indicate that the radiation error is roughly proportional to the temperature of the gases.

The paper concludes with a determination of the nature of the relation between the radiation error and the size of the hot junction of a thermocouple.

DEVELOPMENT OF SCIENTIFIC METHODS OF MANAGEMENT IN A MANUFACTURING PLANT

BY SANFORD E. THOMPSON, WILLIAM O. LICHTNER, KEPPELE HALL, AND HENRY J. GUILD[1]

THE development of scientific methods in manufacturing is being recognized almost universally as an essential to economical management. We say *recognized,* but this must be qualified by the acknowledgment that in the majority of concerns who accept this as a theory the treatment has been superficial instead of covering the development of plans which are accurate, exact, based on facts, and which account for all variable conditions. An encouraging feature of the situation lies in the fact that the most scientifically managed shops realize that they have by no means reached the ideal. In fact, a truly scientific development necessarily shows up the deficiencies as it proceeds. On the other hand, too many plants are settling back into self-sufficiency after establishing a so-called *efficiency department*—a most worthless piece of mechanism as ordinarily conducted—and a *cost system* which at best indicates how money is lost, and not how conditions can be improved.

SCOPE OF PAPER

A large proportion of the published matter relating to the application of scientific methods of management has pertained to the machine shop. In this paper it is the aim of the authors to present in considerable detail an outline of the development of scientific methods as applied to the ordinary manufacturing plant. At the same time, to make this more of a concrete illustration, the discussion will be centered in the plants known as the Eastern Manufacturing Company at Bangor and Lincoln, Maine, one of the largest concerns in the country manufacturing writing paper as its final product.

The development of scientific methods at these mills, however, is not, as one might assume, descriptive of simply a single and comparatively localized industry. As a matter of fact, the processes involved in pulp and paper making are similar in type, so far as management methods—not in specific technique—are concerned, to a vast number of industries. The treatment, for example, involves the scientific development and standardization of processes; the job analysis of hand and machine operations; the systematizing of stores, including supplies, raw materials and material in process; the introduction of planning methods to control very diverse conditions; the training of the worker; and the coöperation of the workers with the management through the Service Department, and personal relations.

In treating the subject, it is proposed after a brief summary and a statement of general principles to take up the plan of control of manufacturing and the methods adopted in the different processes to standardize practice.

INITIAL CONDITIONS IN THE PLANT

The plant at Bangor manufactures writing paper of high grade and also operates its own pulp mill, part of the product of which is for use in the paper and a part for sale. The Bangor mills employ some 800 people.

The individual processes group themselves into

1 manufacture of sulphite pulp from spruce wood
2 manufacture or making of paper from rags and sulphite pulp
3 finishing of the paper to produce the various finishes required for writing paper.

With the last is included the manufacture of the wooden boxes or cases for shipping the paper.

Before beginning the introduction of the more intimate analysis of the methods and processes, the plant had been brought during the previous two years to a stage much above the average plant of the old type of management in efficient operation. In 1914 it was decided by the directors to introduce scientific methods so as to go down to the bottom of things and develop standard methods of handling materials and labor.

RESULTS

The results secured by the scientific standardization of the various operations in combination with the routing system and bonus plan are briefly as follows

[1] Superintendent of Paper Mill, Eastern Manufacturing Co., Bangor, Maine. Other authors are members of the Society.

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a increase in production in the paper mill of 35 per cent
b increase in the pulp mill from 35 tons to 50 tons, or 42 per cent
c average increase in wages of 40 per cent
d reduction in cost per ton of paper production, notwithstanding increased wages, of about 25 per cent[1]
e saving amounting to several thousand dollars per month in materials
f control of production throughout the plant
g development of the spirit of coöperation between management and employees.

The reduction in cost in spite of the increase in wages is due to three things
1 fewer employees per unit of work
2 reduction of overhead costs through the increase in production with the same plant and non-productive help
3 savings in materials.

THE PROCESS OF PAPER MAKING

Paper making, today, both in method and machinery, is substantially the same as it was one hundred years ago. It has been carried on during all this time by using traditional methods transmitted from one generation to another.

The process consists in brief of beating the "furnish," that is, the raw materials, in a large tub or beating engine, passing this through jordan machines, and then on to the paper machine, after which it is cut and finished in a multitude of ways.

SCOPE OF DEVELOPMENT

Scientific management consists fundamentally in finding the best way of doing a thing and putting the plan into execution.

The logical process in the development of scientific methods is to begin with the handling, classification, and storage of the raw materials; next establish control of the manufacturing processes, and finally establish by scientific investigation standards of material and standard practice for operating the plant.

It is evident that there are two distinct features involved in this: *first,* the introduction of a system in management, and *second,* the establishment of standards. It must be recognized very clearly—and it is because of lack of appreciation of this point that scientific management is confounded with mere mechanism—that system alone is never in itself the goal. System is merely the tool and a necessary tool for control. It is the classification of facts, the job analysis, the intimate study of conditions, that produce the real results in output, in quality, in elimination of fatigue, in basic coöperation and pulling together between the men and the management.

These are principles of general application. The actual work to be accomplished presents in different manufacturing establishments problems singularly alike. The methods of procedure, for example, at the Eastern Manufacturing Company, were similar to those required in almost any plant operating under the ordinary type of management.

PLAN OF ORGANIZATION

The work was undertaken in accordance with the following plan

1 classify the product so as to eliminate the confusion caused by a multiplicity of trade names and designations for the same article, and permit of keeping a proper balance of stock of the various grades, weights, colors, sizes, and finishes for promptly filling orders.
2 develop a system of routing controlled by a central planning department that will
   insure orders being filled in the proper sequence
   designate the required material for every order
   eliminate wasted time of men and machines by always having a definite job ahead of each operator and each machine
   move materials promptly from one operation to another with a minimum amount of confusion and delay.
3 make scientific job analysis of every operation to establish standards of materials and practice with an increased output, and yet no undue exertion; and fix rates and bonuses based on these scientific studies that will permit of a largely increased wage to the worker and decreased cost of production.
4 develop the personnel of the whole organization—management and employees—to a point that will insure a large measure of coöperation by functionalizing duties, by training, by assuming responsibilities, by recognizing merit, and by encouraging any expression of thought which will facilitate the work in any way whatever.

[1] This applies to conditions before the recent increase in cost of raw materials.

CONTROL THROUGH THE PLANNING DEPARTMENT

The Planning Department, centrally located in the Finishing Department Building, now controls in complete detail the progress of each order through the mill. The advantages gained over the old method are manifold and obvious

a It has placed in the hands of the two men who are responsible for the filling of all orders—the Production Man of the Making Department (formerly Assistant Superintendent) and the Production Man of the Finishing Department (formerly Boss Finisher)—absolute control of the sequence in which they shall be run. They decide *when* the work is to be done, the one, when the paper is to be made, and the other, when it is to go through the finishing department.
b It affords these production men precise information as to the exact status of any order in the mill at any time without leaving the room.
c Each clerk in the planning department has some definitely specified duty to perform and detailed instructions as to just how to do it. There is thus a trained corps of men and women, each an expert on his own job, who are employed in planning in advance the details of each step of the foreman or of the workman himself after the job has been started.
d The condition of each department and of every machine or worker in that department as regards supply of work is shown by the planning department control board, and permits the shifting of employees from one department to another, in order to prevent congestion of work or lost time on machines.
e It is impossible for anyone to be out of work without the fact being known. In fact, conditions can be foreseen and provisions made to meet them.

FUNCTIONS OF PLANNING DEPARTMENT

The Planning Department performs the following functions
a receives all orders from the Sales Department and acknowledges them the day they are received with a promised date of shipment

b determines the sequence in which jobs are to be run

c it routes each individual order to the machines and work places at which the different operations are to be done, sometimes weeks ahead of the starting of the order

d makes out in advance the time tickets which will be given to the operators when they are assigned a job

e keeps each machine and work place supplied with work

f directs and controls the moving of materials and orders from operation to operation

g transfers operators from one job to another so that every worker in the mill always has some defined task to work on.

PLANNING THE MAKING OF PAPER

The chief aims in routing the materials and planning the running of the different kinds of paper is to (1) produce uniformity of product, (2) reduce number of furnishes, (3) get the paper out on time, and (4) avoid changes on the machines by grouping orders. Careful planning of the runs avoids loss of time in shut-downs, and also permits the arrangement of colors to avoid extensive washing up, so that whites can be runs consecutively, and when colors are run that the changes be made from dark to light instead of from light to dark; also changes in deckle width can be laid out to best advantage.

To accomplish these aims the production man of the making department accumulates the different orders, determines from his records, not merely by memory, the time required for each kind of paper, and plans out the dates when the various lots can be run to the best advantage, and from this order of work the production man prepares a schedule or running list for each of the three paper machines. The route sheets and "stores issues" are made, indicating the way each order is to be handled, and the material is to be used, and the individual time tickets are made out and posted.

ECONOMY AND QUALITY DUE TO UNIFORMITY IN BEATING

One of the fundamental processes of paper making is the treatment in the beating engines. The importance of uniformity in a process like this is little appreciated. The product must come up to a certain standard, and it is very necessary from the standpoint of cost, not merely that this standard be maintained, but also that material be not wasted by improper mixtures, and to provide for unnecessary variations.

STANDARDIZATION OF BEATING

The strength of the product resulting from the beating is dependent upon the length of time and manner of beating the fibers, which is controlled by the set of the beater roll. The variables which had to be considered and studied in the making of paper are

1 control of amount of bone dry stock put into beaters
2 control of density of stock, that is, percentage of water
3 development of proper method of beating for maximum strength, this being dependent upon set of beater roll at start and the varying of beater roll during the process of beating
4 development of proper methods of testing for
   a density
   b fiber length
   c fiber strength
   d slowness
   e set of beater roll
   f hand sheets
   g velocity of stock in beater
   h strength of each of the raw materials
5 determination of relation between proper method of beating and proper method of jordaning and of running on paper machine.

The investigations of these various conditions have been carried on so that at the present time it is possible to know what is going into each furnish, both as to percentages of raw materials and density, and to fix definite times of beating with certainty of uniform results in product. With the information already obtained it is now possible to continue the more intimate investigation with a view to even more definite control.

Through the investigations already made and the routing of the materials and labor, the saving in materials has reached a sum of several thousand dollars per month.

INCREASE IN OUTPUT OF PAPER MACHINES

During the period while the investigation was being made on the beaters it was found advisable to increase the output of the paper machines. This could be accomplished in three ways (1) by increasing the speed of the machines; (2) widening the sheet on the paper machine, or, as it is technically known, increasing the deckle width, and (3) reducing the number and length of shutdowns through better planning of the orders.

Investigation showed that the speeds of the machines for the same furnish at different times would vary as much as 50 per cent through variation in the condition of the stock and lack of uniformity. As a result of the studies definite speeds were established for each furnish and specified to the man on the machine with each order. It was found possible to increase the speeds materially over the average of the old speeds.

The output was further increased by increasing the deckle width of the paper from time to time. The number and length of the shutdowns were reduced through careful planning of the runs.

REDUCTION OF HOURS

The hours were reduced in the Finishing Department in January, 1916, from $55\frac{1}{2}$ to 50 per week. The bonus times were left the same and no piece rates were increased, so that the actual labor cost to the company was increased. However, a comparison of outputs in a single department indicated that the parties on piece work maintained the same production in the shorter day that they had been turning out in the longer day.

STANDARDIZATION IN THE SULPHITE PULP MILL

During the progress of the development in the paper mill, steps leading toward the standardization of methods in the sulphite pulp mill were in progress, and soon, as a result of the satisfaction with the bonus system in the paper mill, there was a demand on the part of the men for the introduction of bonuses in the pulp making.

The problem was of particular interest because, on account of the continuous process, the wood, after the preliminary treatment in the wood room, passed through to the finished pulp without handling. The output is chiefly controlled by the men handling the digesters which cook the chips. The results were accomplished by scientific studies of the different processes, which determined the standard methods to follow to produce the greatest uniformity. The cooks, for example, were given definite curves of temperature and pressure to follow, and

were given bonuses for keeping within the limits set. This resulted in a reduction in the time of cooking, a greater uniformity in product, and the development of initiative on the part of the workmen. A curve has been plotted giving a comparison of the cooking time before and after the establishment of standards, and shows how greater uniformity was obtained. As a result of this uniformity the time of cooking was reduced materially and the output largely increased.

CLASSIFICATION OF PAPER

In analyzing the affairs of any manufacturing establishment producing a great number and variety of articles, the lack of systematic classification of the product is evident. It frequently occurs that no list of the various items can be found, and that there are very imperfect records of the sales of each. This company makes a great variety of grades of paper in many different colors, sizes and weights, and it is necessary to standardize the names of the product before the product itself can be standardized. A mnemonic symbol system was devised and is now in general use. By means of the symbol which is composed of letters and figures, the grade, base weight, color, size and finish of any paper is clearly indicated.

As a result of the classification, it was found possible to reduce the number of grades and to clearly define the amount of stock to carry. With the aid, also, of the running inventory or balance sheets it is possible not merely to keep track of stock on hand but to know just when new stock in any grade should be made up.

PERSONNEL

Scientific management is essentially a system of development—development of methods, and a development of the individual. A man or woman must be trained in order to become an efficient and skilful worker and to demand and receive high wages. Furthermore, a personal development must be attained to give a broadening point of view, so that he may see and appreciate the values of sincerity and truth, health and right living, self respect and self expression.

To further these aims a Service Department was organized under the direction of a trained social worker. The functions of this department are to

a employ all help and to keep a set of employee's record cards
b maintain a library for free circulation of books
c maintain a dispensary for treatment and care of sick or injured
d operate a cafeteria at which wholesome food may be served to employees at cost
e inspect the factory and see that it is maintained at high standards as regards cleanliness, ventilation, sanitation, and safety
f hear all complaints of employees regarding wages, treatment or conditions; investigate every complaint and when necessary see that matters are adjusted so that justice is always done.
g hear all complaints of foremen and department heads regarding employees; investigate these thoroughly and concur in any discipline or discharge that may be administered
h coöperate with employees in furthering any suggestions offered in regard to activities of a recreative or social nature
i coöperate with all outside interests, municipal or private, that may have for their object the betterment of conditions in the community.

DISK-WHEEL STRESS DETERMINATION

By S. H. Weaver,[1] Schenectady, N. Y.

THIS paper describes and applies a simplified method for determining the centrifugal stresses in a disk wheel of given irregular shape of section. Stodola's disk theory is assumed, together with his formula for disks of hyperbolic-section profile. The formulæ are then transformed so as to give the tangential stresses at the inner and outer radii in terms of the radial stresses, ratio of radii and shape constant of disk section.

For a given disk with a single hyperbolic outline, the tangential stresses are expressed in terms of the radial stresses or loads; and if the latter are known, the stresses are determinate. In case the disk-section outline would require to be fitted by two hyperbolas meeting at the same thickness of disk, the wheel section can be divided at the meeting point of the curves into two imaginary rings. The rings at the meeting point, by the continuity of material and same thickness, are held together by a radial stress common to both and have the same elongation and tangential stress. One can then write the tangential stress of the other at their common radii, giving one equation with one unknown quantity, the radial stress common to both, and all stresses are determinate. Thus any irregular shaped disk can be fitted with n hyperbolas, divided into n imaginary rings, and $(n-1)$ equations written for the common meeting points of the curves with $(n-1)$ unknown radial stresses, and the stress problem is solvable.

The solution of the stresses is given by formulæ containing six coefficients whose values are given as functions of the ratio of radii and hyperbolic outline of disk section. These coefficients are laborious to calculate, but should be used for accurate results. For commercial work, approximate equations are given which cover the practical disk proportions, and within the limits shown have a range of error of less than one per cent.

As a further labor-saving device when a number of disks are to be estimated, the approximate equations can be placed in an alignment-chart form. An appendix gives the range and proportion of the five charts required, which experience has shown to be the most useful. The number and size of these charts for accurate reading do not permit of reproduction.

A practical example is given showing the actual application to the usual disk wheel.

Clinkers in Boiler Furnaces. During many years' experience in designing, testing, improving, and operating furnaces, used for many purposes, no branch of this subject has been found that requires more consideration than the troublesome formation of clinkers in the furnace and the formation and growth of clinkers on furnace linings. In a great majority of cases this trouble can be either greatly reduced or avoided, for clinkers are formed by the fusion of the ash and refuse from the combustion of the coal in the furnace.—*Elec. Wld.*, Feb. 10.

[1] General Electric Company.

For presentation at the Spring Meeting, Cincinnati, Ohio, May 21 to 24, 1917, of The American Society of Mechanical Engineers. On account of the mathematical nature of the paper its scope only is indicated here. Advance copies of the paper may be obtained by members gratis upon application.

INDUSTRIAL SAFETY PAPERS

At the Industrial-Safety Session of the Spring Meeting, to be held under the auspices of the Society's Sub-Committee on Protection of Industrial Workers, will be presented and discussed a proposed code of safety standards for industrial ladders. This is one of a series of similar codes which this sub-committee has in preparation or in contemplation.

PROPOSED CODE OF SAFETY STANDARDS FOR INDUSTRIAL LADDERS

Contributed by the Sub-Committee on Protection of Industrial Workers of The American Society of Mechanical Engineers

The word "SHALL" where used is to be understood as mandatory and "SHOULD" as advisory.

DEFINITIONS

The term *Fixed Ladder* as used in these regulations means a ladder that is substantially fastened to a structure in a fixed position.

The term *Portable Ladder* as used in these regulations means a ladder with but one section, which is used transiently at various locations.

The term *Extension Ladder* as used in these regulations means a ladder consisting of two or more parallel sections traveling in guides or brackets so arranged that it may be adjusted to variable lengths.

The term *Portable Step Ladder* as used in these regulations means a ladder so constructed as to be self-supporting.

The term *Fire Ladder* as used in these regulations means a ladder used exclusively for fire purposes.

The term *Trolley Ladder* as used in these regulations means a ladder the movement of which is confined in permanent guides or ways at top or bottom, or both.

The term *Sectional Ladder* as used in these regulations means a ladder consisting of two or more sections so constructed that the sections will telescope into each other.

The term *"A"-Ladder* or *Scaffold Ladder* as used in these regulations means a ladder whose parts, each equivalent to a straight ladder, are hinged at the top to form equal angles with the base.

SECTION 1 GENERAL

a Where stairways are not provided, fixed ladders should be used for access to elevated positions; where fixed ladders are not suitable, portable ladders should be used.

b Ladders shall be numbered, or otherwise designated, and regular inspections shall be made of their condition.

c The use of broken or weak ladders, or ladders with missing rungs, is prohibited.

d When defects develop to such an extent that the ladder is to be permanently discarded, it shall be destroyed.

e Side rails, where wood is used, shall be straight-grained. Knots one-half (½) inch or less in diameter will be permitted when they are in the center of the rails. The following thoroughly seasoned woods should be used: Northern spruce, Oregon pine, Norway pine, yellow long-leaf pine, or Oregon fir.

f Rungs shall be inserted in holes in the side rails and kept from turning, and shall not exceed fourteen (14) inches in length at the top.

g Wooden rungs shall be straight-grained, free from splinters, and absolutely free from knots. The following woods should be used: White ash, white oak (3rd growth), or hickory.

h Steps, where wood is used, should be constructed of the following woods: Northern spruce, Oregon pine, Norway pine, or oak.

i Ladders shall have a uniform step or rung spacing of twelve (12) inches on centers. [Mason ladders having a uniform spacing on centers of ten (10) inches and fire ladders having a uniform spacing of fourteen (14) inches excepted.]

j Ladders shall be equipped with devices designed to prevent slipping. (Fixed ladders, portable step ladders, and "A"-ladders excepted.)

SECTION 2 FIXED LADDERS

Ladders designed to reach safety valves, cut-outs, etc., where speed of operation may mean a saving of life, should always be of a permanent type, securely fastened, and constructed of steel or iron.

a Ladders having side rails are preferred to the type made of U-shaped section embedded in wall or fastened to stack, etc.

b The pitch of ladders shall not be such that a man's position is necessarily below the ladder when climbing.

c Side rails, where metal is used, shall be not less than three-quarters (¾) of a square inch in cross-section. A minimum size of two (2) inches by three-eighths (⅜) inch should be used. Where wood is used, they shall be not less than six (6) square inches in cross-section and shall be dressed on all sides. A section one and three-quarters (1¾) inches by three and three-quarters (3¾) inches (2 by 4 dressed) would be suitable for this purpose.

d Splice plates, where metal is used, shall be of the same size and material as side rails and shall be double-riveted or bolted. Bolts or rivets shall be countersunk on inside and shall be not less than one-half (½) inch nor more than five-eighths (⅝) inch in diameter, where cross-section does not exceed that of two (2) inches by three-eighths (⅜) inch. Where wood is used, there shall be splices on outside of side rails and joints shall be double-bolted. Carriage bolts shall be used. All splice pieces shall be chamfered at the ends.

e Rungs should be round. Where solid metal is used, they shall be not less than five-eighths (⅝) inch in diameter; where pipe is used, they shall be of equivalent strength; where wood is used, they shall not be less than one and one-half (1½) inches in diameter and the tenon shall be at least one (1) inch in diameter or its equivalent in strength.

f Distances from front of rungs to nearest permanent object back of the ladder shall be not less than six and one-half (6½) inches. There shall be a space clear of all obstructions in front of the ladder from bottom to top, of at least thirty (30) inches forward and of at least fifteen (15) inches either side of the center line of the ladder. [Ladders equipped with wells (cages) or their equivalent shall be excepted.]

g Ladders over thirty (30) feet in length should be pro-

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vided with wells, unless the ladder is built in zig-zag sections and provided with platforms between sections.

h Fastenings shall be made of material equivalent in strength to the rails. Fastenings shall be made to wall by building in, by through bolts, or by expansion bolts grouted or leaded. The maximum vertical distance between fastenings or braces shall not be in excess of ten (10) feet.

i Ladders to landing shall extend a distance of at least forty-five (45) inches above the landing, preferably being goosenecked. The rungs may be omitted above the roof. Where a man must step a greater distance than eighteen (18) inches from ladder to roof, tank, etc., a platform shall be provided.

SECTION 3 PORTABLE STRAIGHT LADDERS

a Ladders over thirty (30) feet in length should not be used.

b Side rails shall have a minimum cross-section equivalent in strength to a northern spruce side rail of the following dimensions:

Up to and including 10 ft.	2⅜ x 1⅜ in.
Over 10 ft. up to and including 18 ft.	2¾ x 1⅜ in.
Over 18 ft. up to and including 26 ft.	3 x 1⅝ in.
Over 26 ft. up to and including 30 ft.	3½ x 1⅞ in.

c Side rails should be spread so that the width of the ladder at the bottom will be greater than the width at the top, preferably by a taper of one-quarter (¼) inch per foot of length.

d Rungs shall be equivalent in strength and wear to an ash rung of the following dimensions:

	Diameter	Tenon
Up to and including 24 in. in length	1¼ in.	⅞ in.
Over 24 in. up to and including 30 in. in length	1⅜ in.	⅞ in.

e Portable ladders should be fully protected at their bases to prevent slipping. For use on wood or earth the bases should be provided with case-hardened steel spurs; or a disk similar to the one furnished by the National Affiliated Safety Organizations, consisting of a case-hardened disk, held in position on dowel pins by springs, cotters and nuts, is recommended. These spurs shall be kept sharp. On concrete floors, pivoted shoes with lead or carborundum faces may be used.

f When used on iron floors an attendant should be placed at the foot of each ladder.

g Whenever possible to use ladders with a gooseneck or hook at the top, these should be provided, as forming the best protection against accident.

SECTION 4 EXTENSION LADDERS

a Table 1 should be followed in the construction of extension ladders.

b Ladders should be equipped with safety locks.

SECTION 5 FIRE LADDERS

a The construction, use and maintenance of industrial fire ladders shall conform to the specifications herein set forth covering portable straight ladders (Section 3, Par. *a* excepted).

b A uniform step or rung spacing of fourteen (14) inches shall be used.

c Fire ladders should be painted red and shall be plainly marked "For Fire Purposes Only."

d Fire ladders shall not be used for any other purpose than that for which they are intended.

SECTION 6 PORTABLE STEP LADDERS

a Ladders over twenty (20) feet in length shall not be used.

b Side rails shall have a minimum cross-section equivalent in strength and wear to a northern spruce side rail of the following dimensions:

Up to and including 12 ft.	⅞ x 3 in.
Over 12 ft. up to and including 16 ft.	1 x 3½ in.
Over 16 ft. up to and including 20 ft.	1 x 4 in.

c Front and back rails shall be so spread when the ladder is open that the spread at the bottom, inside to inside, shall be greater than the spread at the top, inside to inside, by an amount equal to or greater than one and one-half (1½) inches per foot of length of ladder. Minimum width between side rails at the top step, inside to inside, shall be not less than twelve (12) inches, with a taper of at least one (1) inch per foot of length of ladder.

d Steps shall be equivalent in strength and wear to a northern spruce step of the following dimensions:

Up to and including 12 ft.	¾ x 4½ in.
Over 12 ft. up to and including 16 ft.	⅞ x 4¼ in.
Over 16 ft. up to and including 20 ft.	1 x 4½ in.

e Steps shall be trussed and screwed or bolted to the side rails. Nails shall not be used as sole fastenings.

f An automatic locking device to hold the front and back rails securely in position shall be an integral part of each ladder.

TABLE 1 CONSTRUCTION OF EXTENSION LADDERS

Side Rails:

Up to and including 44 ft. long: Material, Norway pine, clear and straight-grained, free from knots.

48 ft. to 60 ft. long: Material, Oregon fir, clear and straight-grained, free from knots.

Rungs:

Material: Oak, ash or hickory, straight-grained, free from knots, and live and tough.

Dimensions: 1¼ in. diameter at center; taper to 1⅛ in. diameter, straight-turn to ⅞ in. diameter for holes in side rail.

Ladder Dimensions

Length, ft.	Dimensions of side rails (cross-section same at both ends), in.	Distance between side rails, top section, in.	Distance between side rails, bottom section, in.	Vertical distance between rungs, in.
20, 22, 24, 26	2¾ x 1⅛	12¼	14¾	12
28	2¾ x 1¼	14¼	17	12
32, 36	2¾ x 1⅜	14	17	12
40	3¼ x 1⅜	15¾	18¾	12
44	3¼ x 1⅜	17¾	20¾	12
48, 52	3½ x 1½	17½	20¾	12
60	3¾ x 1¾	18	21¾	12

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f Distances from front of rungs to nearest permanent object back of the ladder shall be not less than six and one-half (6½) inches. There shall be a space clear of all obstructions in front of the ladder from bottom to top, of at least thirty (30) inches forward and of at least fifteen (15) inches either side of the center line of the ladder. [Ladders equipped with wells (cages) or their equivalent shall be excepted.]

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c Side rails should be spread so that the width of the ladder at the bottom will be greater than the width at the top, preferably by a taper of one-quarter (¼) inch per foot of length.

d Rungs shall be equivalent in strength and wear to an ash rung of the following dimensions:

	Diameter	Tenon
Up to and including 24 in. in length. .	1¼ in.	⅞ in.
Over 24 in. up to and including 30 in. in length	1⅜ in.	⅞ in.

e Portable ladders should be fully protected at their bases to prevent slipping. For use on wood or earth the bases should be provided with case-hardened steel spurs; or a disk similar to the one furnished by the National Affiliated Safety Organizations, consisting of a case-hardened disk, held in position on dowel pins by springs, cotters and nuts, is recommended. These spurs shall be kept sharp. On concrete floors, pivoted shoes with lead or carborundum faces may be used.

f When used on iron floors an attendant should be placed at the foot of each ladder.

g Whenever possible to use ladders with a gooseneck or hook at the top, these should be provided, as forming the best protection against accident.

SECTION 4 EXTENSION LADDERS

a Table 1 should be followed in the construction of extension ladders.

b Ladders should be equipped with safety locks.

SECTION 5 FIRE LADDERS

a The construction, use and maintenance of industrial fire ladders shall conform to the specifications herein set forth covering portable straight ladders (Section 3, Par. *a* excepted).

b A uniform step or rung spacing of fourteen (14) inches shall be used.

c Fire ladders should be painted red and shall be plainly marked "For Fire Purposes Only."

d Fire ladders shall not be used for any other purpose than that for which they are intended.

SECTION 6 PORTABLE STEP LADDERS

a Ladders over twenty (20) feet in length shall not be used.

b Side rails shall have a minimum cross-section equivalent in strength and wear to a northern spruce side rail of the following dimensions:

Up to and including 12 ft.	⅞ x 3 in.
Over 12 ft. up to and including 16 ft.	1 x 3½ in.
Over 16 ft. up to and including 20 ft.	1 x 4 in.

c Front and back rails shall be so spread when the ladder is open that the spread at the bottom, inside to inside, shall be greater than the spread at the top, inside to inside, by an amount equal to or greater than one and one-half (1½) inches per foot of length of ladder. Minimum width between side rails at the top step, inside to inside, shall be not less than twelve (12) inches, with a taper of at least one (1) inch per foot of length of ladder.

d Steps shall be equivalent in strength and wear to a northern spruce step of the following dimensions:

Up to and including 12 ft.	¾ x 4½ in.
Over 12 ft. up to and including 16 ft.	⅞ x 4¼ in.
Over 16 ft. up to and including 20 ft.	1 x 4½ in.

e Steps shall be trussed and screwed or bolted to the side rails. Nails shall not be used as sole fastenings.

f An automatic locking device to hold the front and back rails securely in position shall be an integral part of each ladder.

TABLE 1 CONSTRUCTION OF EXTENSION LADDERS

Side Rails:
Up to and including 44 ft. long: Material, Norway pine, clear and straight-grained, free from knots.
48 ft. to 60 ft. long: Material, Oregon fir, clear and straight-grained, free from knots.

Rungs:
Material: Oak, ash or hickory, straight-grained, free from knots, and live and tough.
Dimensions: 1¼ in. diameter at center; taper to 1⅛ in. diameter, straight-turn to ⅞ in. diameter for holes in side rail.

Ladder Dimensions

Length, ft.	Dimensions of side rails (cross-section same at both ends), in.	Distance between side rails, top section, in.	Distance between side rails, bottom section, in.	Vertical distance between rungs, in.
20, 22, 24, 26	2¾ x 1⅛	12¼	14¾	12
28	2¾ x 1¼	14¼	17	12
32, 36	2¾ x 1⅜	14	17	12
40	3¼ x 1⅜	15¾	18¾	12
44	3¼ x 1⅜	17¾	20¾	12
48, 52	3½ x 1½	17½	20¾	12
60	3¾ x 1¾	18	21¾	12

SECTION 7 "A"-LADDERS OR SCAFFOLD LADDERS

a Ladders over twenty (20) feet in length should not be used.

b Side rails shall have a minimum cross-section equivalent in strength and wear to a northern spruce rail of the following dimensions:

Up to and including 12 ft.	$1\frac{1}{4} \times 2\frac{3}{4}$ in.
Over 12 ft. up to and including 16 ft.	$1\frac{1}{2} \times 3$ in.
Over 16 ft. up to and including 20 ft.	$1\frac{1}{2} \times 3\frac{1}{2}$ in.

c Side rails shall be so spread that the width of the ladder at the bottom, inside to inside, shall be greater than the width at the top, inside to inside, by an amount equal to or greater than one and one-half ($1\frac{1}{2}$) inches per foot of length of ladder.

d Supports shall be equivalent in strength and wear to an ash bearing one (1) inch by two (2) inches. They shall be straight-grained and absolutely free from knots, shall have tenons not less than five-eighths ($\frac{5}{8}$) of an inch by two (2) inches, secured in place with wire nails. They shall be not less than three (3) inches from the top of the side rails. They shall be eighteen (18) inches on centers, and shall be staggered. The tops of side rails shall be cut on a bevel to prevent them from spreading. Hinges shall be wrought or malleable iron, bolted or riveted to side rails.

SECTION 8 TROLLEY LADDERS

a Ladders shall be suspended from tracks fastened securely to the ceiling or to the framework with which the ladders are connected. Tracks should be of wrought iron or wood, and should be tested to double the maximum of load for marginal safety. Tracks shall be constructed so that it is impossible for the wheels to jump the track, by having the wheels in pairs situated on opposite sides of a vertical flange or by having the track so shaped that it completely encloses the sides of the wheels. The extreme front and back wheels shall have a horizontal distance of at least eighteen (18) inches between their centers.

b The track wheels shall be rigidly fastened to the top of the ladder with suitable steel or wrought-iron brackets. These brackets may be fastened to a bolt connecting the two side rails of the ladder or to the top step. In the latter case the top step shall be provided with extra metal braces to the side rails.

c Side rails shall have a minimum spread, inside to inside, of ten (10) inches.

d Side rails shall have a minimum cross-section equivalent in strength and wear to a northern spruce side rail three and one-half ($3\frac{1}{2}$) inches by seven-eighths ($\frac{7}{8}$) inch.

e Steps shall be equivalent in strength and wear to a northern spruce step four and three-quarters ($4\frac{3}{4}$) inches by three-quarters ($\frac{3}{4}$) inch.

f Steps, where metal is used, shall be flanged downward not less than two (2) inches at both ends and secured by two bolts or rivets to each side rail. Where wood is used, they shall be inset in the side rails one-quarter ($\frac{1}{4}$) inch, glued and nailed; all, or at least alternate steps, shall be braced to the side rails with metal brackets placed under the steps.

g The base of the ladder shall rest on two wheels or castors.

SECTION 9 SECTIONAL LADDERS

a The bottom section shall be six (6) feet in length and shall have a minimum spread between rails at the base, inside to inside, of twenty-one (21) inches.

b Sections (intermediates) shall be six (6) feet in length and shall have a minimum spread between rails at the bottom, inside to inside, of thirteen (13) inches.

c The top section may converge with a minimum spread between rails at the bottom, inside to inside, of thirteen (13) inches.

d Side rails shall have a minimum cross-section equivalent in strength and wear to a northern spruce side rail of the following dimensions:

Up to and including 5 sections	$2\frac{3}{4} \times 1\frac{1}{8}$ in.
Over 5 sections	$3\frac{1}{8} \times 1\frac{1}{8}$ in.

e Rungs shall be equivalent in strength and wear to an ash rung one and three-sixteenths ($1\frac{3}{16}$) inches in diameter with seven-eighths ($\frac{7}{8}$) inch tenon.

SAFE PRACTICES

Use care in placing portable ladders before using them. If there is danger of ladder's slipping, have some one hold it. Do not place ladders too straight or at too great an angle, or they may fall, break or slip.

Never place ladders in front of doors opening toward the ladder.

Ladders should never be placed against window sashes. Screw a board across top of ladder to give bearing at each side of window.

Step ladders should be fully opened and locked in all cases before any one steps on them.

Always face ladder when ascending or descending.

Do not go up or down a ladder without free use of both hands. If material has to be handled, use a rope.

Never slide down a ladder.

Never use broken or weak ladders or ladders with missing rungs.

When defects of construction develop to such an extent that the ladder is discarded, it should be destroyed.

Ladders withdrawn from service for repairs should be sent to the repair shop or tagged as "Dangerous—DO NOT USE."

See that ladders you use have safety feet, and, where necessary, safety hooks at top.

Short ladders should not be spliced together, as they are not strong enough to be used as long ladders.

Safe practice demands that ladders be numbered, classified, and subjected to careful and periodic inspection. Ladders should be kept clean and free from dirt or splashings of paint or material. Imperfections or defects are not readily observed unless ladders are kept in good condition.

Iron and steel ladders should be coated with a preservative paint or composition. Wooden ladders, if used out of doors, should also be carefully treated with a suitable preservative.

A satisfactory practice is the storing of ladders upon brackets by arranging them against wall in such manner as to permit inspection without moving ladders.

Storage of ladders involves a separate problem. Shelter should be provided in all cases. If placed upright, 75 degrees will afford a safe angle; if racks are used, place the ladder on edge rather than flat; this will prevent trouble and danger of accident in withdrawing the ladder for use.

Safety bolts and hooks should be provided when the character of the work demands the attention of the workman or constitutes an element of danger.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of The Journal by members of The American Society of Mechanical Engineers are solicited by the Publication Committee. Contributions particularly welcomed are suggestions on Society Affairs, discussions of papers published in The Journal, or brief articles of current interest to mechanical engineers.

Reply to Comments on Welding Paper

To the Editor:

In reply to the several persons who entered into the discussion of my paper on welding by the metal-pencil electric-arc method, printed in the April issue of The Journal, I do not think that the term *autogenous* applies to this particular form of welding, because it so closely follows the cycle of conditions of ordinary forge welding, whereas in autogenous welding, fluidity is a necessary condition. The pencil form is the last form developed and ought to be differently named, since it actually is in the added metal the lowest-temperature weld of the newer forms.

In reply to Mr. McCabe, the temperatures in question are estimated from the color. In the metal-pencil electric-arc welding, watched through colored glasses, just the same putty-like condition occurs as in the ordinary forge welding. The estimate may be either above or below the actual temperature; it is used, more than for any other reason, to direct notice to the fact that fluidity is not a condition present in this last-developed form of spot welding, except that known as the Quasi Arc.

As to the elimination of the possible stresses set up in the weld, the figures as quoted by Mr. McCabe cannot apply to this form of welding. In this case the area is very much less, and being free from the highly expanded condition of fluidity (in many cases almost reaching vaporization), the differential for each degree of temperature is different and the internal stress less. However, no attempt is made to eliminate internal stresses, nor is this necessary, because these stresses are at a maximum only when new, and are constantly changing as time elapses. This is true of any of the later forms of welding wherein the bulk of the work is always cold and the part worked on made hot. The point to recognize here, and this is fairly well explained in my paper, is that in this form of welding these internal stresses are the least of any and consequently more readily and sooner neutralized. With this consideration, therefore, no differential per degree of temperature can be used.

The determining of the safety of a vessel by the electrostatic test is new to me. What I am familiar with is the hydrostatic test, and this is perfectly trustworthy when accompanied by hammering while the test is on, the test being applied to the customary amount, that is, one-half more than the running pressure under which the vessel is to work.

It is to be expected that the welding material would vary widely in any form of welding except the approved form of welding, which may vary some, but not widely, and except the form that my paper defends, and Mr. McCabe is justified in his conclusion regarding this, but I would suggest that the metal-pencil form of electric-arc welding should not be made to carry the burden of the failures of autogenous welding generally, since this form places the art on a newer and entirely different and safer basis.

In reply to Mr. Bierbaum, the disturbance of the adjacent metal is dwelt upon in my paper and was shown in the lantern slides used at its presentation, and these ought to be a conclusive answer. It is true that in all other forms of welding wherein fluidity is resorted to, the disturbance is considerable, and one slide used by Mr. Armstrong in further discussion of my paper shows the adjacent metal practically destroyed. I wish to dwell strongly on the fact that in this metal-pencil electric-arc method no such condition exists, and the adjacent metal is not disturbed to a fraction of the extent of that which takes place in gas and carbon-arc welding and in the approved form of welding embodied in the A.S.M.E. Boiler Code and entitled Forge Welding, and this is due to the extremely localized character of the process and also its great rapidity of action,—it does not have time enough to overheat so as to create the disturbance referred to.

In reply to Mr. Armstrong, his discussion practically embodies a paper in itself and describes a further improvement in this particular form of welding, viz: the metal-pencil electric arc, but wherein fluidity obtains as a condition; but this occurs to a degree beyond which it does not go and is controllable to a nicety, approaching as is described in my paper an automatic action, which can be depended upon to prevent vaporization or any carelessness regarding overheating exactly in the way I have described, and altogether analogous thereto. In analyzing this extended discussion, however, in his references to the chemistry of these welds Mr. Armstrong refers to the oxidizing which occurs around the crater when the metal pencil is fused. Now to obtain fusion a high voltage must be used with electrodes of this character, and the arc maintained abnormally long. In his slides this is shown, and he states "about $\frac{1}{8}$ in." as the length of such arc, but it is safe to say that it must be more since the slides themselves show dimensions as practically full size, as in Fig. 3 and Fig. 4, page 315 of the April issue of The Journal.

While these metal arcs require more voltage than the arcs obtained otherwise, the voltages used with the pencil arcs are normally low, from 60 to 70, and with such voltages an arc cannot be held with a wire in size equal to 0.161 in. diameter or No. 8 B.W.G. more than about $\frac{1}{16}$ in. Therefore, fusion under such conditions cannot take place, and the piece of plastic putty-like metal flies for the plate, being constantly pulled into it, and consequently does not have time to become fused and the oxide does not amount to enough to deserve any considerable attention. However, the little that is present in what Mr. Armstrong terms the *bare wire* is almost entirely absent in the slag-covered wire, and though a predetermined limited amount of fusion occurs, the deposited metal shown in the slides shows a remarkable similarity to the metal of the plate it joins. These slides also show the least disturbance of the adjacent metal and the added metal is as he says, "just the same as ingot steel." Taking his discussion in a general way, it is a strong vindication of the supremacy of the metal-pencil electric-arc method of welding, showing a remarkable and highly efficient improvement in the art.

Mr. Armstrong introduces for the first time the question of

corrosion as being associated with welding and lays considerable stress upon it. In this regard I wish to say, however, that I have seen many pieces of forge welding wherein no corrosion has ever appeared; thousands are in evidence, such, for instance, in chains, wagon tires and innumerable things of every-day occurrence, pieces wherein this claim is absolutely absent. Test pieces which I have furnished the Society and which have now been in their possession about a year, welded with pencil method, show absolutely no indication of corrosion. However, I claim that in the several other methods of welding referred to in this discussion, wherein fluidity takes place, disturbances are set up which produce conditions wherein the question of corrosion may be a consideration, but not under the form of welding in my paper, nor is it present in the improved form of welding which Mr. Armstrong advocates, nor in the approved form of welding in the A.S.M.E. Boiler Code.

In reply to Mr. Mauck if he means that the metals "in all processes of welding" have to be raised to the point of fusion and no more, that is, just a plastic condition, then his discussion is not a criticism of the metal-pencil electric-arc welding, since that is just what takes place therein.

If there are no leaks when a moderate hydrostatic test to $1\frac{1}{2}$ times is applied, it shows that there are no porous or spongy places,—that the joint is solid. Then why a higher test? I do not think it necessary or advisable to carry the testing pressure to extremes and so unduly strain the vessel.

In conclusion, let me say that with the knowledge we have in our possession, derived from much investigation, many experiments and tests, all reduced to tables and curves, we now know just the right voltage to use, just how much current to have, just what are the right size pencils, together with proper direction of current, and the knowledge also which enables us to utilize other factors such as magnetism, slag protection and purifying agents. The process now contains nothing haphazard or problematical; it has been reduced to an exact science, and, therefore, belongs in the list of things that have become considered as settled.

E. A. WILDT.

Scranton, Pa.

WORK OF THE BOILER CODE COMMITTEE

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York City.

Below are given the interpretations of the Committee as approved by the Council on April 20, 1917, in Cases No. 136 to 139, 141, 142, 144 and 145. In this report, as previously, the names of inquirers have been omitted.

CASE NO. 136

Inquiry: Is it the intent that no pressure shall again be allowed on a boiler on which a crack has been discovered in a longitudinal seam, and that the boiler cannot be patched and again used, or may such a boiler be again put in commission after being patched and after passing a prescribed test?

Reply: It is the intent of Par. 384 to permanently discontinue the use of the shell or drum of a boiler, for steam boiler purposes, should a longitudinal joint crack be discovered in any plate or course of the shell or drum.

CASE NO. 137

Inquiry: Is it permissible under Part 1, Section 2 of the Boiler Code, to use a smaller size of safety valve than is there specified, where a heating boiler is operated on the vapor system with open vents to the atmosphere?

Reply: It is not expedient to modify or amend the Code in the nature you request. Par. 348 and 358 cover your case, and refer to the boiler and not to the system.

CASE NO. 138

Inquiry: Is it permissible in a superheater constructed with steel return bend headers to electrically weld the tubes into the headers?

Reply: Autogenous welding of superheater tubes to headers is not permissible under the Boiler Code if the strength of the weld be depended upon to resist the pressure tending to drive the tube out of the header. It is permitted for the sake of the tightness, but the strength of the weld at the joint must not be taken into account.

CASE NO. 139

Inquiry: Is it possible to secure a smaller A.S.M.E. Boiler Stamp than the present $\frac{3}{4}$ in. stamp that is furnished to meet the requirements of Par. 332 of the Boiler Code? It is difficult to stamp thin plates with the present $\frac{3}{4}$ in. stamp on account of the rebound.

Reply: A new stamp will be provided, $\frac{1}{2}$ in. size, hammer type, and with the top end square, so that it can be either used as a hammer stamp or struck with a sledge.

CASE NO. 141

Inquiry: Is there any objection to drilling and tapping holes in the shell of a boiler if they are properly reinforced?

Reply: It is the opinion of the Boiler Code Committee that there are no objections to drilling and tapping holes in the shell of a boiler if the same are properly reinforced according to the Code.

CASE NO. 142

Inquiry: In a design of horizontal return tubular boiler, with a manhole located in the front head below the tubes, is it permissible under Par. 218 to insert tubes on either side of the manhole instead of through stays?

Reply: Tubes on each side of a manhole cannot be used in place of the through stays specified in the last sentence of Par. 218.

CASE NO. 144

Inquiry: What are the requirements for the design of reinforcing liners for the inside of the cylindrical shell of a boiler?

Reply: Where reinforcement is necessary for openings which are not intended for pipe threads, the requirements of Par. 261 of the Boiler Code are to be followed.

CASE NO. 145

Inquiry: Is it not better practice under Par. 316 of the Boiler Code to discharge feed water in the waterleg of a vertical firetube boiler about half way between the mud ring and the bottom head, than to discharge it against the tubes midway between the bottom head and the lowest water level?

Reply: It is the opinion of the Boiler Code Committee that Par. 316 does not permit of discharging the feed water in the waterleg of a vertical firetube boiler.

Society Affairs

Engineering Survey

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED[1] LIST OF OFFICERS AND COMMITTEES

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SOCIETY REPRESENTATION

American Association Advancement of Science
American Society Testing Materials, Joint Conference Committee
American Society for Testing Materials, Modification Briggs Standard for Pipe Threads
Classification of Technical Literature
Conference Committee on Electrical Engineering Standards
Conference Committee of National engineering Societies
Conservation
Engineer Reserve Corps
Engineering Foundation
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Increase of Membership, A. L. Williston
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Machine Tools Standardization
Metric System, L. D. Burlingame
National Museum
Nominating Committee
Patent Laws
Pipe Threads, International Standard, Edwin M. Herr
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Refrigeration, D. S. Jacobus
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- Sub-Committee on Cutting Action of Machine Tools, Leon P. Alford
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- Sub-Committee on Investigation of the Clinkering of Coal, Lionel S. Marks
- Sub-Committee on Lubrication, Albert Kingsbury
- Sub-Committee on Materials of Electrical Engineering
- Sub-Committee on Safety Valves
- Sub-Committee on Steam, Flow Meters, R. J. S. Pigott
- Sub-Committee on Worm Gearing, Fred A. Halsey

Student Branches, Frederick R. Hutton
Tellers of Election, Robert H. Kirk
Tolerances in Screw Thread Fits, L. D. Burlingame

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[1]A complete list of the officers and committees of the Society will be found in the Year Book for 1917, and in the March, 1917 issue of The Journal.

SOCIETY AFFAIRS

A Record of the Current Activities of the Society, Its Members, Council, Committees, Sections and Student Branches; and an Account of Professional Affairs of Interest to the Membership

THE officers of the Society are trying to make every member feel that this is a national society of the engineering profession. President Jacobus, last year, and President Hollis, this year, have made great sacrifices of their time and energy in order to visit the Sections, and I have supplemented their trips and have just returned from as far west as Oklahoma City.

The first place I visited was Cincinnati, where I met the Local Committee, who are arranging for the Spring Meeting. If they carry out the program they have planned, the Meeting will be the most complete I have known of, not only of this Society but of any other.

From Cincinnati, I went to Chicago to attend a conference on Engineering Coöperation, called by Dr. F. H. Newell, Mem.Am.Soc.M.E. An account of this conference appears elsewhere in this issue of The Journal. As I have lived a number of years in the West, I appreciate the point of view of a man who lives away from the headquarters of the national societies.

The theory on which these organizations, of which there is a large number, representative of the smaller societies as well as the larger societies, have gotten together, is that the engineering profession owes a duty to society and ought to take a part in public affairs, and the members of these organizations are correspondingly dissatisfied with the attitude of the National Engineering Societies in what they regard as an ultra-conservative policy.

Is it a proper ambition for an engineering society to aspire to such a position with relation to civic affairs that engineering matters coming up in the administration of communities be referred to the society? If so, how can it be fulfilled? This is a broad question which should be thought about carefully. Should engineering societies take a part in public affairs? What part should they have in public affairs?

Our Council is laboring with this problem sincerely, and is trying to strike the happy medium between avoiding taking sides on political and economic questions and giving engineering advice on matters which we do know about.

From Chicago, I went to Madison to the Student Branch there. We have forty-four Student Branches in the Universities and are getting the young men interested in engineering societies. They have their own societies and presiding officers. They have outside lecturers and papers presented by their own members. They learn how to speak in public before their mates. We are supplying, through the activities of the engineering societies, a feature which is not supplied by the majority of colleges in their regular curricula.

From Madison I went to Milwaukee, where we had a splendid meeting with members of the local committee of the Milwaukee Engineering Society, which is the nucleus about which the locals of the national engineering societies there gather. Then I returned to Chicago, where I met the Chicago local committee.

I then went to the Student Branch of the State College of Iowa and to the University of Kansas Student Branch, where they had an Annual Meeting which lasted all day, all arranged for by the students themselves and being addressed by outside lecturers. From there I went to the University of Oklahoma, just outside Oklahoma City, and in one of the coming states of the United States.

Just before I left New York on this journey, the Military Engineering Committee wrote to the presidents of each of the National Engineering Societies, suggesting that the ex-

FELLOW MEMBERS

It is not necessary to call the attention of the Society to the unprecedented crisis before this country, because we all, as American citizens, know well that our country has embarked upon an undertaking fateful to the freedom of the individual.

The word "Democracy" does not express fully all that would be in store for us if we, as a nation, failed to do our duty by humanity, and by our country. Happily every member of our Society can assume that every other member is eager to make his contribution. I have been struck with that in the great amount of correspondence I have had during the past month, always asking the question, "How can I serve my country?"

The Society as a whole is doing all it can to coöperate effectively with the National Research Council, with the Council of National Defense, and with the War and Navy Departments, in the appointment of representatives to assist and coördinate the work of all engineering societies. Two of our members were selected for the National Research Council, two for the Council of National Defense, two for work with an Army Board on guns, and doubtless others will come forward, or be brought forward as the exigency arises.

As good citizens we should truly awake to the necessity of a well-trained army. We, as engineers, can help in this, not only by offering ourselves to the War Department and to the Navy Department, but also by assisting unselfishly in the industries, and in the promotion of increased farm production.

In our democracy we can best raise an army by sharing alike in its hardships, not trusting that the noblest and best of our young men will come forward to enlist for service, but putting the responsibility on all alike through some kind of universal service.

I have no permission to speak for the whole Society, but as its President, I urge every member to search his own conscience seriously for some method by which he can serve. The country depends upon us and we must respond.

IRA N. HOLLIS

isting Committee be reinstructed and authorized to get out a complete set of instructions as to what a man should do who wished to serve his country. The Committee is now called The Joint Committee on National Defense and has, during the past month, prepared two circulars to send out to the membership with instructions as how to join the Army and the Navy. We will send these out shortly.

A number of our members have responded to the call for national service, as the Roll of Honor published this month shows. This list will be supplemented from month to month by the names of members as they are enlisted. This first list is incomplete in the particular of commissions received by members in the Engineer Officers' Reserve Corps, the War Department having at this date issued a list of accepted commissions to March 15 only. Members who have accepted commissions in the Corps subsequently to this date, and any other members entitled to have their names inserted in the Roll of Honor, should notify me immediately.

The National Research Council has solicited the nomination of two of our members for their Engineering Committee and the Council of National Defense has advised us that they similarly will request us to nominate members for their Engineering Committee.

Calvin W. Rice,
Secretary.

Council Notes[1]

At the meeting of the Council on March 16 the following members were present: Ira N. Hollis, *President,* John H. Barr, C. H. Benjamin, R. H. Fernald, Arthur M. Greene, Jr., W. B. Gregory, F. R. Hutton, W. B. Jackson, D. S. Jacobus, C. T. Main, H. de B. Parsons, John A. Stevens, Wm. H. Wiley, *Treasurer,* and Calvin W. Rice, *Secretary.*

A.S.M.E. Boiler Code. The Chairman of the Committee proposed changes in the Code, together with interpretations in cases Nos. 140 and 143, which were approved and ordered published in The Journal. They appeared in the April issue.

Engineering Coöperation Conference. Paul P. Bird, H. C. Gardner, and Calvin W. Rice were appointed to represent the Society at a conference on Engineering Coöperation to be held in Chicago, March 28 and 29.

Military Engineering Committee. It was voted that the Committee on Engineer Officers' Reserve Corps of The American Society of Mechanical Engineers, which is part of a joint committee, coöperate with the other engineering societies and the United States Government, so that there will be one central committee of the engineering profession which shall assist the Government, and that the committee has power to select a suitable name, also to add to its membership, and that The American Society of Mechanical Engineers will be willing to assume its proportionate share of the expenses of a comprehensive work of advancing the preparedness for national defense.

Standardization Committee. C. F. Hirshfeld was appointed on this committee in place of H. G. Stott, deceased.

Student Branches. A student branch at the University of Oklahoma, Norma, Oklahoma, was approved.

Calvin W. Rice
Secretary.

On page 370 of the April issue of The Journal it was stated that the price of the book on The John Fritz Medal is $4.00. This is erroneous. The price is $2.50.

[1] The April Journal went to press before the March Meeting.

Past Presidents' Return from the Orient

Dr. Brashear, Mr. Swasey and Mr. Freeman have returned safely from their extended tour of the Orient, and were entertained at luncheon at the Engineers' Club of San Francisco on April 3. Vice-President Dickie has sent us a first-hand account of the reception, which is well worth reproduction in full:

It was no ordinary occurrence that brought out one hundred and seventeen of the best-known engineers of San Francisco on Tuesday April 3 to luncheon at the Engineers' Club. It is not often possible to have as guests at one time, three ex-presidents of one of the national societies, but fortune favored the engineers who practice their profession in the city of the Golden Gate. For in through that Western Gateway there floated three wise men from the Far East, such men as the engineer, be he civil, electrical, or mechanical, delights to honor—Dr. Brashear, Mr. Swasey, and Mr. Freeman.

Mr. C. T. Hutchinson, president of the club, and Mr. Shreve, chairman of the entertainment committee, secured the three noted engineers, who were seeking rest rather than excitement, and brought them to the club rooms, where they were received with manifest tokens of good will and respect and at 12.30 all proceeded to the dining room. Mr. Dickie acted as chairman, and after luncheon, with a few remarks appropriate to the occasion, introduced first Dr. Brashear who, in a beautiful address, carried these hard-working sober engineers up with him on angels' wings so that they might gaze for a while on the very heaven of heavens, and feel what engineers seldom feel—the bliss of wings and the glorious vision of distances that can only be measured in terms of light years. But after a hearty luncheon neither the doctor nor his audience could stay long up where he had drawn them, so gradually he let them down and talked awhile about the common things of the engineer's checkered career. This fifteen-minute address was a gem and will be long remembered by those who had the privilege to hear it.

The chairman then called upon Mr. Swasey for a few words, which resulted in a very helpful address on the growing importance of the engineer in the work of the world. Mr. Swasey said that while this old, selfish world was rather slow in acknowledging its great debt to the engineer, it has at last found out that it cannot even fight to any purpose without the engineer—and so he encouraged the young engineers before him, with the thought that their profession was a militant one, and that the future would become brighter for the engineer as the years rolled by.

Mr. Freeman spoke on the outlook of the Panama Canal, giving his experience as a member of the commission appointed by the President to investigate the effect of the landslides on the security of the canal as a reliable passage for shipping between the two oceans. Mr. Freeman, in a lucid address, cleared away any doubts that might be in the minds of his hearers, and what he said will always be referred to when the subject is under discussion.

The meeting with these three typical men in our profession will not soon be forgotten by those, especially the younger members, who had the rare opportunity to hear them; and it should also be noted that Dr. Brashear, Mr. Swasey and Mr. Freeman expressed their delight in having the opportunity to meet so many of the engineers of San Francisco.

If the student of engineering gets his training in the English classroom only, it is, at best, artificial; at worst, only speaking pieces. For training of this sort there is opportunity (and it is being taken advantage of) in engineering "topics" classes; but the best place is in the engineering society. If this is a student organization with faculty assistance and if students who really know something of some particular engineering problem and practising engineers make up the program, in the discussion of which all take part, such a society can accomplish more in training students to speak effectively than an unaided English teacher ever could.—*Engineering Education,* February 1917.

THE ENGINEERING SOCIETIES IN NATIONAL DEFENSE

THE JOURNAL takes great satisfaction in announcing the active participation in national affairs by members of the Society as fully set forth in the Society Affairs and Engineering Survey sections of this number.

The Society has been honored by the election of Prof. W. F. Durand, former president of the International Engineering Congress, to the National Academy of Sciences. This is in keeping with the announcement last year of the intention of the Academy to create a division of engineering coördinate with other divisions of the Academy, and from time to time to elect engineers to membership.

Mr. John R. Freeman has been elected a member-at-large of the National Research Council of the Academy of Sciences. Mr. Freeman, and Dr. W. F. M. Goss, already a member of the Research Council, have been designated as the Society's representatives on that body.

At the meeting of our Council on April 20, President Hollis reported that he and Dr. D. S. Jacobus had been selected by the Secretary of War as representatives of the Society on a special engineers' commission to serve with officers of the Army and Navy in determining gun mounts.

The following nominations were also made in response to invitations received from the National Research Council and the Advisory Committee of the Council of National Defense:

For membership on the Engineering Committee of the National Research Council, of which committee Mr. Gano Dunn, Mem.Am.Soc.M.E., is chairman, Prof. W. F. Durand and Charles D. Young.

For appointment on an Engineering Societies' Section of the commission of the Advisory Commission of which Dr. Hollis Godfrey, Mem.Am.Soc.M.E., is chairman, Dr. Ira N. Hollis and Calvin W. Rice.

In response to the request of the Director of the Bureau of Mines, the Council has nominated its Research Committee as a special advisory committee to the Bureau, and has also authorized the President to appoint two sub-committees, one on fuels and another on mine equipment. Prof. O. P. Hood, Mem.Am.Soc.M.E., and mechanical engineer at the laboratories in Pittsburgh, has been designated by Director Manning as secretary of the advisory committee of the engineering societies to the Bureau.

Mr. Frank A. Scott, vice-president and treasurer of The Warner and Swasey Company, has been appointed head of the General Munitions Board, as is noted in the Engineering Survey Section in this issue. Mr. Scott's appointment is one of the evidences of the helpfulness of the Society in the present crisis.

At the request of THE JOURNAL, the following letter has been prepared by Mr. Dunn, in which is clearly explained the relations of the engineering societies to the various agencies of national defense.

Letter from Mr. Gano Dunn, Chairman Engineering Committee, National Research Council

TO THE EDITOR:

The engineering profession, which has been so prompt to volunteer its professional and military services to the Government in support of national defense, is now in contact with the various government agencies, as follows:

First, through the Naval Consulting Board and its formerly existing Committee on Industrial Preparedness, with the origin and organization of which board the engineering profession is already familiar. Each of the national engineering societies, and certain other societies, by contributing two members to the Naval Consulting Board, has afforded the Navy and War Departments and the Council of National Defense a highly expert board for passing upon inventions and developing them in the new Government Laboratory that has been organized.

ENGINEERS' RESERVE CORPS

Second, in a more or less informal way, through the joint Committee on Engineers' Reserve Corps and the Military Engineering Committee of New York, the military services of engineers are being organized and offered to the Government, and an Engineers' Regiment is recruiting in New York.

The constitutions of the national engineering societies were found to contain such limitations that these societies could not take formal action in military matters. A little over a year ago the Military Engineering Committee organized itself through the spontaneous action of a group of leading engineers, including a number of presidents, past-presidents and other prominent officers of the national engineering societies, to an extent that gave the committee a character representative of those societies, although this character has only recently been confirmed by the action of the societies themselves.

NATIONAL RESEARCH COUNCIL

Third, through the National Research Council, created at the request of President Wilson by the National Academy of Sciences, "to bring into coöperation existing governmental, educational, industrial, and other scientific and research organizations, with the purpose of encouraging investigations of natural phenomena, the increased use of scientific research in the development of American industries, the employment of scientific methods in strengthening the national defense, and such other applications of science as will promote the national security and welfare."

The work of the National Research Council, the offices of which adjoin the offices of the Council of National Defense, is carried on through the agency of central committees covering each of the physical sciences and chemistry, mathematics, medicine, hygiene, agriculture and other subjects, including a Committee on Engineering. To this Committee on Engineering, each of the national engineering societies has contributed two representatives, and stands ready to contribute others as called for. With the engineers who are members of the National Research Council, these constitute the Engineering Committee.

The representatives so far named from the American Society of Civil Engineers are George F. Swain, Edgar C. Marburg and Clemens Herschel; from the American Institute of Mining Engineers, Pope Yeatman, Albert Sauveur, Charles F. Rand and George K. Burgess; from The American Society of Mechanical Engineers, W. F. M. Goss, John R. Freeman, C. D. Young, Wm. F. Durand, John A. Brashear, Hollis Godfrey, Howard E. Coffin and Ambrose Swasey; from the American Institute of Electrical Engineers, Frank B. Jewett, Clayton H. Sharp, Gano

Dunn, C. E. Skinner, Michael I. Pupin, S. W. Stratton, Elihu Thomson and John J. Carty; from the American Institute of Consulting Engineers, Lewis B. Stillwell.

This Engineering Committee, under formal request of the Council of National Defense, in a resolution dated February 28, 1917, addressed to the National Research Council, brings to the aid of the Council of National Defense, directly through its director, the professional services of engineers in the realm of engineering research, and it constitutes the connection between the Council of National Defense and the various national engineering societies, through which services offered by those societies to the President of the United States may be called upon in the solution of problems in scientific and engineering research.

In addition to supporting the Government in engineering research, this committee also brings to the aid of the Government, through the National Research Council, such general engineering services as are auxiliary to research where those services are needed by any of the other committees of the Council as incidental to research problems on which they are at work.

The national engineering societies have a further relation to the National Research Council through the Engineering Foundation which those societies established to administer the munificent gift of Ambrose Swasey for the fostering of research in science and engineering. Through the action of the engineers, the whole available income from this gift is now devoted to the organization and operation expenses, but not the research expenses, of the Council.

As has been stated, the contact of the engineering profession with national defense, through the Engineering Committee of the National Research Council, covers only those services involved in science and engineering research, with the addition of such general engineering services as are auxiliary.

Other or general services in the engineering field are articulated with the national defense, as follows:

COUNCIL OF NATIONAL DEFENSE

Fourth, through an Engineering Section of that committee of the Advisory Commission of the Council of National Defense, which is under the direction of Dr. Hollis Godfrey, to whom the Defense Council has assigned supervision of general engineering matters, including education.

Dr. Godfrey is now in course of completing the formation of this committee by calling upon each national engineering society, and certain other engineering societies, to contribute two representatives whom he may appoint members of the Engineering Section of his committee, so that services needed by the Council of National Defense in the realm of general engineering may be placed at its disposal, either by the individual members of the committee or through them by other members of the engineering societies upon whom the Council of National Defense may call.

The above four channels indicate the broad extent to which the members of the engineering profession, in patriotic response to the country's need, have come forward to render services.

Yours truly,

GANO DUNN, *Chairman, Engineering Committee, National Research Council.*

The following is the text of letters received from the National Research Council and the Advisory Commission of the Council of National Defense inviting nominations from our Society on the Engineering Committee of the former and on the Engineering Societies' Section of the latter:

FROM ADVISORY COMMISSION OF COUNCIL OF NATIONAL DEFENSE

The American Society of Mechanical Engineers tendered its services to the President of the United States in support of the National Defense, and these services were accepted by the President who referred further relations with The American Society of Mechanical Engineers to the Council of National Defense.

As the member of the Advisory Commission of the Council of National Defense charged with matters pertaining to engineering, and authorized by virtue of my appointment by the President and by Act of Congress to appoint Committees for the purpose of assisting the Council of National Defense with advice on the carrying out of its plans, I desire to ask if you will designate two representatives from The American Society of Mechanical Engineers whom I may appoint members of an Engineering Section of my Committee, which representatives will be the means of putting The American Society of Mechanical Engineers into relations with the Council of National Defense so that the services offered by your Society may be available to the Council.

Upon the completion of the formation of the Engineering Section of my Committee, I desire to ask the representatives of the National Engineering Societies to meet me for a conference in Washington to make further plans by which the Government may derive the greatest benefit from the services those Societies have so patriotically tendered.—HOLLIS GODFREY, *Member Advisory Commission Council of National Defense.*

FROM THE NATIONAL RESEARCH COUNCIL

The National Research Council to increase its means of serving the Government in support of National Defense by enlisting through an Engineering Committee the services of a group of distinguished engineers drawn from the field of engineering research in each of the four main divisions of civil, mining, mechanical and electrical engineering.

In addition to services in the field of engineering research the Council has need of some general engineering services auxiliary to problems of research, and desires to be in a position to enlist such services in support of the general objects of the Council.

These objects are, to bring into coöperation existing governmental, educational, industrial and other research organizations with the purpose of encouraging the investigation of national phenomena, the increased use of scientific research in the development of American industries, the employment of scientific methods in strengthening the national defense, and such other applications of science as will promote the national security and welfare.

The relation of the National Research Council to the Council of National Defense is indicated by the following resolution, passed on the 21st of February, by the latter:

> RESOLVED, that the Council of National Defense recognizing that the National Research Council, at the request of the President of the United States has organized the scientific forces of the country in the interest of national defense and for national defense, and to this end the Council of National coöperate with it in matters pertaining to scientific research for national defense and to this end the Council of National Defense suggests that the National Research Council appoint a Committee of not more than three, at least one of whom shall be located in Washington, for the purpose of maintaining active relations with the Director of the Council of National Defense.

The Executive Committee of the National Research Council would appreciate if on behalf of The American Society of Mechanical Engineers, you would designate two engineers skilled in engineering research, whom the Committee may appoint members of the Engineering Committee of the National Research Council, to render the services outlined in this communication and to serve as a means of calling upon other members of The American Society of Mechanical Engineers, for services that the National Research Council may need in support of the National objects herein referred to.—GEORGE E. HALE, *Chairman, National Research Council;* JOHN J. CARTY, *Chairman, Executive Committee;* GANO DUNN, *Chairman, Engineering Committee.*

ROLL OF HONOR

Members of The American Society of Mechanical Engineers Enlisted in the National Service

(First List)

ADAMS, CARROLL E., Private, Battery A, Rhode Island National Guard.

ADAMS, WALTER H., Captain, Engineer Officers' Reserve Corps*

ALLEN, WALTER C., Captain, Engineer Officers' Reserve Corps.

ALLISON, JOHN F., First Lieutenant, 3d Regiment, Penn Machine Gun Company, Fort Bliss, Texas.

ALLYN, ROBERT S., Major, 9th Coast Defense Command, C. A. C., National Guard, New York.

BEHR, F. J., Captain, Coast Artillery Corps, U. S. A., Hammond Radio Research Lab., Gloucester, Mass.

BELCHER, P. WILLIAM, First Lieutenant, Engineer Officers' Reserve Corps*

BENEDICT, B. W., Captain, 1st Illinois Field Artillery, commanding Battery F.

BERLINER, R. W., Captain, Engineer Officers' Reserve Corps.

BETTS, PHILANDER, Major, Engineer Officers' Reserve Corps.

BILGER, H. E., Captain, Engineer Officers' Reserve Corps*

BILLMYER, CARROLL D., Corporal, First Company, Coast Artillery Corps, National Guard of Virginia.

BIRNIE, ROGERS, Colonel, Sandy Hook Proving Ground, Fort Hancock, N. J., and Governor's Island, N. Y.

BOETTGER, ROBERT, First Lieutenant, Engineer Officers' Reserve Corps.

BRENNAN, JAMES, Captain and A.D.C., 7th Division, U. S. A.

BURROUGHS, JOS. H., JR., First Class Private, Company B, Engineer Battalion, National Guard, Pennsylvania.

BUSH, HAROLD M., Major, Ohio Battalion of Artillery, National Guard.

BUYERS, A. S., First Lieutenant, Coast Artillery Corps, U. S. A., care of Adjutant-Gen'l, U. S. A., Washington, D. C.

CAMPBELL, E. D., Captain, Engineer Officers' Reserve Corps*

CARLSSON, CARL A. V., Ordnance Engineer, Navy Dept., Ordnance Office, Navy Yard, Washington, D. C.

CATTELL, WILLIAM A., Major, Engineer Officers' Reserve Corps*

CHURCH, ELIHU CUNNINGHAM, Seventh Infantry, New York.

CLUETT, SANFORD L., Major, Signal Corps, New York National Guard.

COMSTOCK, CHARLES W., Second Lieutenant, Field Artillery, National Guard, Colorado.

COOKE, STANLEY S., Private, Troop D, 1st Squadron Cavalry, Colorado National Guard.

COYLE, A. M., Mechanical Engineer, Coast Defense, Board of Engineers, U. S. A.

CRUIKSHANK, BARTON, Captain, R. I., First Cavalry, National Guard, New York.

CURTIS, GREELY S., Lieutenant, Junior Grade, 10th Deck Division, Massachusetts Naval Militia.

DAVIS, FRANCIS P., Second Lieutenant, Coast Artillery Corps, New York National Guard. Assigned to 33d Co., 8th C. D. C.

DAVIS, JAMES H., Second Lieutenant, Coast Artillery Corps, New York National Guard. Assigned to 33d Co., 8th C. D. C.

DELEMOS, SIDNEY R., Captain, Engineer Officers' Reserve Corps.

DEWOLF, ROGER D., Lieutenant, 7th Division, 3d Battalion, Naval Militia, New York.

DOTY, PAUL, Commissary General, rank of Brigadier General, Minnesota National Guard.

DOTY, PAUL, Major, Engineer Officers' Reserve Corps.

DOYLE, M. A., Second Lieutenant, Engineers, U. S. Coast Guard.

EATON, P. B., Second Lieutenant, Engineers, U. S. Coast Guard.

ELMES, CLYDE C., Captain, Engineer Officers' Reserve Corps.

FITZGERALD, EDWARD T., Captain, 2d Battalion, Naval Militia, New York.

FRY, ALFRED BROOKS, Captain, Naval Militia and Engineers' Reserve List, U. S. N.

FULLER, RAY W., Captain, Company A, Engineers, U. S. and Penna.

GILLIS, H. A., Major, Engineer Officers' Reserve Corps.

GREEN, F. W., Captain, Engineer Officers' Reserve Corps.

GREGORY, WILLIAM B., Major, Engineer Officers' Reserve Corps.

GUNBY, FRANK M., Captain, Artillery Engineer, C. A. C., Massachusetts National Guard.

HALL, HARRIS F., Captain, Company M, 6th Infantry, Illinois National Guard.

HERBERT, J. S., Captain, Engineer Officers' Reserve Corps.

HILL, FRANCIS L., Company H, First Virginia Regiment Volunteers.

HOLMES, URBAN T., Commander, U. S. N., Navy Department, Washington, D. C.

HOLMGREN, F. C., Automobile expert, Rock Island Arsenal, Rock Island, Ill.

HUBBELL, LYMAN P., Captain, Quartermaster Corps, 74th New York Infantry, National Guard.

HUNT, LEIGH, Lieutenant, Machine Gun Company, 1st Kansas Infantry, Eagle Pass, Texas.

HUTCHENS, EDWARD, Captain, Engineer Officers' Reserve Corps*

INGHAM, HOWARD M., Corporal, 1st Motorcycle Battery of Englewood, N. J.

IRELAND, MARK L., Captain, Quartermaster Corps, U.S.A.

JAMIESON, CHAS. C., Major, Ordnance Department, U. S. Army ('88-'10).

JENKS, GLEN F., Major, Ordnance Dept., U. S. A., Manila Ordnance Depot, Manila.

JOHNSTONE, EDWARD J., Lieutenant, Junior Grade, Naval Militia.

JUNKERSFELD, PETER, Major, Engineer Officers' Reserve Corps.

KATTE, E. B., Major, Engineer Officers' Reserve Corps.

KESSLER, ARMIN GEORGE, Lieutenant, Senior Grade, Naval Militia, Erie, Pa.

KILPATRICK, JOHN D., Major, Quartermaster Corps, N. J.

KING, CHARLES G. Y., Lieutenant Commander, Illinois Naval Reserve.

KINGSTON, ARTHUR, Lieutenant, 4th Regiment, U. S. Marine Corps.

KRAUS, SIDNEY M., Lieutenant (J. G.), U. S. N., U. S. S. Sampson.

LAMONT, CLARENCE B., Captain, Engineer Officers' Reserve Corps.

LARSEN, CHARLES, First Lieutenant, Engineer Officers' Corps*

LINCOLN, PAUL M., Captain, Engineer Officers' Reserve Corps.

McLEAN, ROBERT W., First Lieutenant, Engineer Officers' Reserve Corps.

McMUNN, WILLIAM N., Commander, Illinois Naval Reserve.

MANSFIELD, JULIAN B., Captain, Infantry and Artillery, Reserve.

MARTIN, KINGSLEY G., Private, Class B, Depot Battalion, 22d Regiment of Engineers.

MAXFIELD, HOWARD H., Captain, Engineer Officers' Reserve Corps.

MERSHON, R. D., Major, Engineer Officers' Reserve Corps.

MILLER, MARTIN NIXON, Chief Building Inspector, Frankford Arsenal, Ordnance, War Dept., U. S. A.

MOON, HARTLEY A., Major, Infantry, 4th Battalion, 3d Regiment.

NEWCOMB, ROBERT S., Captain, Coast Artillery Corps, New York National Guard.

NEWTON, GUY D., Major, Engineer Officers' Reserve Corps*

NORRIS, ALEX. MURDOCH, Ensign, Engineer Duties, Maryland Naval Militia.

OATLEY, HENRY B., Naval Militia.

OHMER, JOHN F., JR., First Lieutenant and Battalion Adjutant, 3d Ohio Infantry.

OSGOOD, WENTWORTH H., Lieutenant, U. S. N., U. S. S. Chester.

OTTO, HENRY S., Private, Squadron A, New York National Guard.

PARKER, CHARLES H., Captain (retired), Massachusetts Naval Militia.

PELLY, JOHN F., Battery A, First Field Artillery, Pennsylvania National Guard.

PELLY, JOHN F., Corporal, Battery A, First Field Artillery, Pennsylvania.

PELOT, JOSEPH H., Major, Ordnance Dept., U. S. A., Frankford Arsenal, Philadelphia.

RATHJENS, G. WILLIAM, Captain, Engineer Officers' Reserve Corps*

REIMER, ARTHUR A., Captain, Engineer Officers' Reserve Corps.

RICHARDSON, EDWARD BRIDGE, Captain, Battery A, Massachusetts Field Artillery.

ROBINSON, WILLIAM, Second Lieutenant, Engineer Officers' Reserve Corps*

SANDSTROM, C. O., Captain, Company L., 3rd Regiment, Mo., Laredo, Texas.

SCHLANK, ELIAS, Private, Sanitary Division, 7th N. Y. Infantry, National Guard.

SCHNEIDER, G. A., First Lieutenant, Engineer Officers' Reserve Corps.

SCOTT, ROSSITER STOCKTON, Corporal, Battery A, Maryland National Guard.

SIMPSON, COLIN C., JR., Private, Depot Battalion, 7th New York Infantry.

SMITH, ALBERT S., Captain, Engineer Officers' Reserve Corps.

SMITH, WILLIAM WALKER, Lieutenant, U. S. N., Pittsburgh, Pa.

STARK, W. E., Second Lieutenant, Engineer Officers' Reserve Corps.

STEEL, REGINALD A., Corporal, Company A, 22nd Corps of Engineers, National Guard, New York.

STRAHLMANN, O. E., Aeronautical Engineer, U. S. Army Signal Corps.

SUMMERS, DANIEL, Second Lieutenant, Engineer Officers' Reserve Corps*

SUTTON, FRANK, Major, Engineer Officers' Reserve Corps.

SWAN, JOHN J., Captain, Engineer Officers' Reserve Corps.

SWIFT, JOHN B., Lieutenant, Company E, 1st Battalion, Illinois Engineers.

TAYLOR, DONALD F., Private, Squadron A, Machine Gun Battery, New York Division.

TAYLOR, L. B., Torpedo Engineer, U. S. Naval Torpedo Station, Newport, R. I.

TOLTZ, MAX, Major, Engineering Corps, Minnesota National Guard.

TREAT, SIDNEY W., Sergeant, 7th Infantry N. G. U. S.

TRUSCOTT, HAROLD S., Captain commanding Co. I, 3d Batt., 4th Inf. Reg., National Guard of Hawaii.

TURNER, ROBERT T., JR., Gunner, N. Y. Training Battery.

VIETS, HARRY A., Sergeant, 13th Coast Defense Command, National Guard, New York.

WAGNER, CHARLES FRANCIS, Captain, Engineer Officers' Reserve Corps.

WAITT, ARTHUR M., Major, Engineer Officers' Reserve Corps.

WESTERVELT, W. I., Major, U. S. A., U. S. Government, Washington, D. C.

WHITLEY, FREDERIC N., Major, First Battalion, New York Engineers.

WHITLOCK, E. H., Major, Engineer Officers' Reserve Corps*

WHITNEY, HERBERT A., Assistant Battery Commander, Coast Artillery, National Guard.

WHITTED, T. B., Captain, Engineer Officers' Reserve Corps*

WILDER, C. W., First Lieutenant Engineer Officers' Reserve Corps.

WILSON, HENRY C., Major, 8th Coast Defense Command, National Guard, New York.

WOOD, HORATIO N., First Lieutenant of Engineers, U. S. Coast Guard, U. S. Cutter Morrill, Detroit, Mich.

WOODRUFF, CLARENCE A., Second Lieutenant, Connecticut Coast Artillery Corps.

YORK, HERBERT W., Lieutenant Commander, Naval Militia, New York.

ZIMMERMAN, OLIVER B., Captain, Engineer Officers' Reserve Corps.

* Acceptance of commission pending at date of latest list from War Department

THE SPRING MEETING AT CINCINNATI

THE record of the Spring Meetings of the Society brings back the most pleasant recollections of good fellowship, inspiration and renewed interest in the affairs of the Society to those who have been fortunate in being present at these meetings. It also calls to mind many gracious hospitalities extended to the Society by friends of engineers in every part of the country in which these meetings have been held.

The entertainment part of the program of the Spring Meeting of The American Society of Mechanical Engineers, to be held in Ohio, May 21 to 24, if carried out as it has been planned by the Cincinnati Local Committee, will make this meeting the most enjoyable one ever held by the Society. The Committee has excelled itself in providing novel and attractive features for this part of the program.

In this anticipation of the good time in store for members and guests attending the meeting, we must not lose sight of the fact that there are serious matters to be considered, and that some of the topics to be presented and discussed at the professional sessions are of vital national importance at this time. The Technical Section of this issue of The Journal is devoted to the papers to be given at these sessions.

A complete program of the meeting is published below. Full information was given in the last issue of The Journal regarding transportation and fares and hotels, and nothing remains now but for members to complete their own arrangements for being present with their guests at the Hotel Sinton, in Cincinnati, on the morning of Monday, May 21.

Below are also given brief biographical notes of the authors of the papers.

Authors of the Papers

J. F. Barkley has been connected with the U. S. Bureau of Mines for about four years, working on fuel problems concerning boiler-room practice, particularly the transmission of heat from the gases of combustion to the boiler water. He has also spent some time with the Westinghouse Electric and Manufacturing Co., partly on heat problems. There are several government publications along the lines of his paper.

Harry L. Coe is vice-president of Harpham, Barnes, Stevenson & Coe, Inc., production engineers of Boston. For the past ten years he has specialized in general production engineering work, factory organizations, types of management and machine production. He has had charge, for the past two years, of the projectile departments of the Vermont Farm Machine Company and the Consolidated Car-Heating Company, manufacturing 3-in. shrapnel.

Adolph L. De Leeuw speaks from a very extended experience, having been designing engineer with the Niles Tool Works Company, mechanical engineer with the Cincinnati Milling Machine Company, and at present is mechanical engineer with the Singer Manufacturing Company. He has written quite a number of papers on the important subject of metal cutting and metal cutters.

John R. Du Priest is at present head of the Mechanical Engineering Department of the University of Idaho, Moscow, Idaho. He is a specialist in gas-engine work, having served as chief engineer with the Columbus Machine Company where complete power plants for pumping, lighting and manufacturing were turned out under his direction. He is the inventor of various new designs in gas and oil-engine machinery.

Otto P. Geier became associated with The Cincinnati Milling Machine Co. three years ago to organize an Employee's Service department. He was formerly superintendent of the Department of Charities and Correction at Cincinnati, and has given a great deal of attention to the problems of public-health work. He is chairman of the section on Preventive Medicine of the American Medical Association, and chairman of the Health Service Section of the National Safety Council.

Henry J. Guild is superintendent of the paper mills of the Eastern Mfg. Company, Bangor and Lincoln, Maine. He has been associated with the development of scientific methods from the beginning and is continuing this development.

Harry V. Haight is at present chief engineer of the Canadian Ingersoll-Rand Company, Ltd., Sherbrooke, Quebec, having for many years served in a similar capacity with the Canadian Rand Drill Company. He has made a specialty of compressed-air machinery, including designing of air compressors, rock drills, coal cutters, compressed-air locomotives, haulage plants and general pneumatic tools.

Keppele Hall has made an intensive study of the Taylor system and in practice as a consulting engineer, associated with Sanford E. Thompson, Mem.Am.Soc.M.E., specializes in the same subject. In this particular line of work he has been employed for the last three years as a resident engineer of the Eastern Manufacturing Company's paper mill.

Arthur L. Humphrey is at present vice-president and general manager of the Westinghouse Air Brake Co. He has had a very wide experience in railroad engineering, having held executive positions with the Union Pacific, Southern Pacific, Colorado Midland, Colorado Southern and other railroads. He has made a specialty of improved shop facilities and modern appliances for economical manufacturing operations.

Horace Judd has been connected with The Ohio State University for the past fifteen years. From 1902 to 1910 he was assistant professor and since 1910 has been associate professor of experimental engineering. During that time his work has been chiefly along the lines of gas, hydraulic, and steam engineering, with more attention during the past few years to hydraulic subjects, especially to the flow of fluids through pipes and orifices.

F. G. Kent is at present works manager of the Lodge & Shipley Machine Tool Company. He was formerly for four years general superintendent of manufacturing with the Pierce-Arrow Motor Car Company. Before that he was associated with The Goodman Manufacturing Company, manufacturers of electrical mining machinery, as works manager. He has a wide and varied experience in machine shop practice, and is a specialist on the subject of organization.

Henry Kreisinger has been connected with the Government fuel investigation for the last thirteen years. He has made a large number of steaming tests of many kinds of fuels and with various boiler equipments. He is now in charge of the fuel-efficiency laboratory of the U. S. Bureau of Mines. His interest is principally given to the study of combustion of coal and heat transmission in engineering problems. He is a co-author of a number of government publications on these subjects.

William O. Lichtner is a member of the firm of Thompson & Lichtner, Consulting Engineers. He specializes in advice on management conditions and on the introduction of scientific methods of management in construction and industrial operations.

Charles Edward Lucke has carried out a great variety of investigations, both scientific and commercial, and has published numerous papers and books on engineering subjects, especially gas-engine design. As head of the mechanical-engineering department at Columbia University he organized new courses and developed new methods of instruction. He has also acted as consulting engineer to various important industrial concerns.

F. W. Marquis has been for the past four years professor of steam engineering at the Ohio State University. Previous to that he was for six years a member of the staff of the Engineering Experiment Station of the University of Illinois. In both of these positions he has devoted much of his time to a study, largely experimental, of steam-using and steam-generating machinery.

Charles Meier has been connected with the Cincinnati Planer Company for the past sixteen years, serving the first eleven years as chief designer and superintendent and the last five years as sales manager and engineer. He has specialized in the developing of metal planers.

Charles B. Nolte has been connected with Robert W. Hunt & Co. for the past seven years, having charge during the latter four years of the inspection of general engineering materials. He has given particular attention recently to the inspection and testing of purchases of artillery, equipment and other important munition materials supplied the European Governments by this country.

J. E. Otterson is at present first vice-president and general manager of the Winchester Repeating Arms Company, New Haven, Conn. He graduated from the Naval Academy and served as an officer in the Navy. He was also graduated as Master of Science by Massachusetts Institute of Technology and served as Naval Constructor in the United States Navy.

Victor B. Phillips has been connected since 1911 with The Cleveland Railway Company which has studied very thoroughly the matter of power policy. The company has investigated at great length questions of purchased-power rates and the rehabilitation of old plants or the construction of new plants, and as a result enjoys the lowest purchase rates for steam-generated power known in this country. As assistant to the Superintendent of Power, Mr. Phillips in the last two years has devoted himself almost entirely to the above problems.

Herman Schneider is Dean of the College of Engineering, University of Cincinnati. He devised and put into operation the coöperative scheme of education whereby students spend alternating bi-weekly periods in seventy-five industrial, construction, and transportation concerns, and at the Engineering College of the University of Cincinnati. The course has been in operation eleven years, and there are five hundred students enrolled in the work.

Sanford E. Thompson is a consulting engineer and member of the firm of Thompson & Lichtner, Consulting Engineers. He has advised on many projects both in lines of construction and investigation and shop management, acting at the present time as consulting engineer in the introduction of scientific methods of management for various concerns.

Frederick A. Waldron has had experience with the Brown & Sharpe Manufacturing Co., Beaman & Smith, and the Yale & Towne Manufacturing Co. With the last mentioned company he worked his way up to the position of superintendent. He has been practising as an industrial engineer for some years, and is chairman of the Sub-Committee on Industrial Buildings of the Society.

Edward T. Walsh has had experience as construction engineer and as mechanical engineer of the Workmen's Compensation Service Bureau. He has been engaged in industrial engineering for more than ten years. He is at present chief engineer of the Canadian Car and Foundry Company, Ltd., in which capacity he has been brought in close touch with the Russian Technical Bureau and Russian Inspection.

S. H. Weaver has been connected with the Schenectady works of the General Electric Company for the past thirteen years. For the greater part of that period he has supervised the mechanical-stress calculations for the varied electrical apparatus that company produces.

Frank O. Wells has been connected with Wells Brothers Co. since 1876, and has been president of the Greenfield Tap and Die Corporation since its organization. He has devoted a great deal of his time during the past several years towards instituting the United States Standard thread in place of the so-called V-thread. Such success as has been achieved towards this end is largely due to the efforts of Mr. Wells, not only in his individual capacity on many occasions, but also as Chairman of the Sub-Committee of the A. S. M. E., to which Committee was referred the matter of standardization of screw thread tolerances. As a step towards preparedness, the Government, at the suggestion of Mr. Wells, and through his personal efforts and the information he placed at their disposal, has done a great deal to standardize and equip private plants with all gages necessary to manufacture munitions and arms.

Lucien J. Yeomans is practising in Chicago as an industrial engineer and is also a patent attorney. He has had wide experience as a production engineer, and specializes in shop organization and methods of cost reduction. He is manager of the Amalgamated Machinery Corporation and patentee of the machine tools manufactured by them.

John Younger is chief engineer of the Truck Division of the Pierce-Arrow Motor Car Company, and has been so for the past five and one-half years. He has specialized in motor-truck design, motor-truck and road-vehicle transportation for the past twelve years.

Enlargement of Engineering Survey Section

In the Engineering Survey Section of this issue of The Journal is taken another step in the policy of the Publication Committee to develop The Journal along lines of increasing usefulness.

From now on the Survey will review important engineering events, as well as the leading articles in technical periodicals, which has heretofore been its distinguishing feature. The new department will be devoted exclusively to professional matters and will include reports of the meetings of other engineering societies, synopses and lists of researches conducted by various laboratories, besides brief articles and items having a more strictly news value.

Engineers are busy men. Few have time to more than keep in touch with the developments in their own specialized fields, and too often in respect only to trade conditions. It is hoped by the Publication Committee that the new development in the Engineering Survey will enable its readers to follow more readily the progress in the various fields in which they may be interested.

Request for January Issues

The demands for copies of the January 1917 issue of The Journal, which contains a full account of the 37th Annual Meeting, have now exceeded the supply, and this issue is temporarily out of stock. Requests for copies are still being made, however, and members who do not desire to preserve permanently their copy of the January Journal are requested to return it to the Secretary, who will remit postage and cost.

Presentation of John Fritz Medal

The John Fritz Medal was awarded in January, 1917, to Dr. Henry Marion Howe, for his "investigations in metallurgy, especially in the metallography of iron and steel."

The presentation ceremonies will take place in the Auditorium of the Engineering Societies Building, at 8:30 p. m., on May 10.

Ambrose Swasey, chairman of the John Fritz Medal Board of Award, will preside and addresses will be delivered by Dr. Rossiter W. Raymond, secretary emeritus of the American Institute of Mining Engineers, Dr. Ira N. Hollis, Presi-

SPRING MEETING PROGRAM

Cincinnati, May, 21-24, 1917

Monday, May 21

10.00 a.m. Opening of headquarters and registration at Hotel Sinton.
2.00 p.m. Council Meeting.
During the afternoon there will be trips to the shops of the city and an inspection visit to the hospital.
8.00 p.m. Informal Reception.

Tuesday, May 22

10.00 a.m. Business Meeting, followed by Professional Sessions.

MACHINE SHOP SESSION

A Foundation for Machine Tool Design and Construction, A. L. DeLeeuw.
Machine Shop Organization, Fred G. Kent.
Metal Planers and Methods of Production, Charles Meier.

GENERAL SESSION

Tests of Uniflow Steam Traction Engines, F. W. Marquis.
Relation of Efficiency to Capacity in the Boiler Room, Victor B. Phillips.
Radiation Error in Measuring Temperature of Gases, Henry Kreisinger and J. F. Barkley.
Development of Scientific Methods of Management in a Manufacturing Plant, Sanford E. Thompson and Associates.
Disk Wheel Stress Determination, S. H. Weaver (by title only).

Excursion for the ladies to Rookwood Pottery and the Art Museum.

2.30 p.m. Joint Session with National Machine Tool Builders' Association, with two addresses:
The Trend in Engineering Training, Dean Herman Schneider.
The Human Potential in Industry, Dr. Otto P. Geier.

Trolley ride for the ladies to Fort Thomas.

8.15 p.m. Smoker for members of the Society and of the National Machine Tool Builders' Association.
Reception for the Ladies.

Wednesday, May 23

10.00 a.m. FIRST MUNITIONS SESSION.

Opening remarks by Major E. D. Bricker, Ordnance Department, Frankford Arsenal, and Lieutenant T. S. Wilkinson, Jr., U. S. N. Bureau of Ordnance.
Munitions Contracts and Their Financing, Frederick A. Waldron.
Organizing for Munitions Manufacture, Arthur L. Humphrey.
Organization for Munitions Manufacture, Harry L. Coe.
Procuring Special Machines for Munitions Manufacture, H. V. Haight.
Practical War-Time Shell Making, Lucien I. Yeomans.

Trip for ladies through leading stores and visit to skyscraper.

2.00 p.m. Boat ride to Fern Bank Dam or Water Works.
8.30 p.m. Informal Dance.

Thursday, May 24

10.00 a.m. Simultaneous Sessions.

SECOND MUNITIONS SESSION

The Design of Munitions for Quantity Manufacture, J. E. Otterson.
Procuring Materials for Munitions, C. B. Nolte.
Limits and Tolerances for the Manufacture of Munitions, A. W. Erdman.
Gages and Small Tools, F. O. Wells.
The Importance of Intelligent Inspection in Munitions Manufacture, E. T. Walsh.

GAS POWER SESSION

The Problem of Aeronautical Engine Design, C. E. Lucke.
Test of a Motor Fire Engine, Horace Judd.
Design of Motor Truck Engines for Long Life, John Younger.
Relation of Port Area to the Power of Gas Engines and its Influence on Regulation, J. E. DuPriest.

INDUSTRIAL SAFETY SESSION

Proposed Code of Safety Standards for Industrial Ladders.

In the afternoon, Motor Car Ride to Mt. Storm, U. C. Observatory, Ault Park; visits to Machine Plants.
On Friday, for those who remain over, there will be an opportunity for trips to Fort Ancient, Mammoth Cave, or to Lexington.

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Professor Albert Sauveur, chairman of the Board at the time the award was made, will present the medal and the ceremonies will conclude with the response of Dr. Howe.

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VAN YORX, JOHN H., JR., Manager of Foundry, Bullard Machine Tool Co., Bridgeport

WILSON, HOWARD B., Efficiency Engineer, New Departure Mfg. Co., Bristol

District of Columbia

GILLIS, IRVIN V., Commander (retired) U. S. Navy, Representing Bethlehem Steel Co. in China

Illinois

KNAPP, LELAND G., Efficiency Engineer, Emerson Co., Efficiency Engineers, Chicago

PITT, ALMA A., President, The Pitt Engineering Co., Chicago

Indiana

BURRELL, BENJAMIN S., Master Mechanic, Inland Steel Co., Indiana Harbor

COREY, DAVID A., Executive Engineer, S. F. Bowser & Co., Inc., Fort Wayne

NOLAND, RALPH W., Instructor in Machine Design, Purdue University, Lafayette

Maryland

FOX, HARRY K., Chief Draftsman, Motive Power Department, Western Maryland Railway Co., Hagerstown

Massachusetts

COGSWELL, LESTER W., Engine Designer, Kinney Manufacturing Co., Boston

DAVIS, SIDNEY L., Production Engineer, Baush Machine Tool Co., Springfield

KNIGHT, FREDERICK D., Superintendent of Construction, Stone & Webster Engineering Corp., Boston

MONTGOMERY, WILLIAM J., Instructor in Machine Work, Brockton High School, Brockton

WILLARD, FRANK H., Assistant General Manager, Graton & Knight Manufacturing Co., Worcester

Michigan

GALLAGHER, WILLIAM H., JR., Electrical-Mechanical Engineer, Wolverine & Mohawk Copper Mining Co., Kearsarge

ROWEN, JOHN H., Commander (Retired) U. S. Navy, and Member of Faculty of Engineering College, University of Michigan, Ann Arbor

SINTZ, CLAUDE, Engineer, Detroit

Minnesota

POLLARD, LAWRENCE E., Sales Engineer, L. E. Pollard Co., Minneapolis

RUFF, DE WITT C., Vice-President, Fire Brick Construction Co., Minneapolis

New Jersey

KOTTENBASH, ERNEST E., Chief Engineer, Schafer Ball Bearings Co., Inc., Hawthorne

MATTHEWS, JOHN B., Marine-Power Engineer, Samuel L. Moore Sons Corp., Elizabeth

MOUNT, RALPH H., Manager, The Okonite Co., Passaic

New York

ABELS, ALOYSIUS J., President, A. J. Abels Co., Inc., Buffalo

BALDWIN, ARTHUR J., Publisher, Vice-President, McGraw-Hill Publishing Co., Inc., New York

CONNER, WILLIAM W., Engineer, Eastman Kodak Co., Rochester

CORLISS, WILLIAM J., State Locomotive Boiler Inspector, Public Service Commission, Albany

DIETER, WILLIAM, Torpedo Engineer, E. W. Bliss Co., Brooklyn

DIVINE, BRADFORD H., President, Divine Brothers Co., Utica

KEARFOOT, WILLIAM D., Marine Engineer, New York

LACY, ROBERT, Estimating Engineer, Otis Elevator Co., New York

MOEN, LECLANCHE, President, C. W. Hunt Co., Inc., New York

WATKINS, ARTHUR M., Secretary, Inter-Continental Machinery Corp., New York

North Carolina

HARDESTY, GEORGE H., Engineer in Charge, State Hospital, Goldsboro

Ohio

BICKETT, CHARLES A., President, The Bickett Machine & Mfg. Co., Cincinnati

CHRYST, WILLIAM A., Chief Engineer, Dayton Engineering Laboratories Co., Dayton

JUPP, ALFRED J., Sales Director, The Lunkenheimer Co., Cincinnati

LYON, GEORGE R., Vice-President, The Power Equipment Co., Toledo

STONE, JULIUS F., President, The Seagrave Co., Columbus

WALTER, FRANK L., Master Mechanic, Dayton Engineering Laboratories Co., Dayton

Pennsylvania

BRESSLER, J. WALTER, Metallurgist, Tacony Steel Co., Tacony

DUNN, J. JAY, General Superintendent, Shelby Steel Tube Co., Ellwood City

FORREST, JAMES, Assistant General Foreman, Baldwin Locomotive Works, Philadelphia

McNARY, JAMES E., Staff Engineer, Lubrication Division, The Texas Co., Pittsburg

SAYLOR, JOHN R., Proprietor, Pottstown Machine Co., Pottstown

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GILLIS, IRVIN V., Commander (retired) U. S. Navy, Representing Bethlehem Steel Co. in China

Illinois

KNAPP, LELAND G., Efficiency Engineer, Emerson Co., Efficiency Engineers, Chicago

PITT, ALMA A., President, The Pitt Engineering Co., Chicago

Indiana

BURRELL, BENJAMIN S., Master Mechanic, Inland Steel Co., Indiana Harbor

COREY, DAVID A., Executive Engineer, S. F. Bowser & Co., Inc., Fort Wayne

NOLAND, RALPH W., Instructor in Machine Design, Purdue University, Lafayette

Maryland

FOX, HARRY K., Chief Draftsman, Motive Power Department, Western Maryland Railway Co., Hagerstown

Massachusetts

COGSWELL, LESTER W., Engine Designer, Kinney Manufacturing Co., Boston

DAVIS, SIDNEY L., Production Engineer, Baush Machine Tool Co., Springfield

KNIGHT, FREDERICK D., Superintendent of Construction, Stone & Webster Engineering Corp., Boston

MONTGOMERY, WILLIAM J., Instructor in Machine Work, Brockton High School, Brockton

WILLARD, FRANK H., Assistant General Manager, Graton & Knight Manufacturing Co., Worcester

Michigan

GALLAGHER, WILLIAM H., JR., Electrical-Mechanical Engineer, Wolverine & Mohawk Copper Mining Co., Kearsarge

ROWEN, JOHN H., Commander (Retired) U. S. Navy, and Member of Faculty of Engineering College, University of Michigan, Ann Arbor

SINTZ, CLAUDE, Engineer, Detroit

Minnesota

POLLARD, LAWRENCE E., Sales Engineer, L. E. Pollard Co., Minneapolis

RUFF, DE WITT C., Vice-President, Fire Brick Construction Co., Minneapolis

New Jersey

KOTTENBASH, ERNEST E., Chief Engineer, Schafer Ball Bearings Co., Inc., Hawthorne

MATTHEWS, JOHN B., Marine-Power Engineer, Samuel L. Moore Sons Corp., Elizabeth

MOUNT, RALPH H., Manager, The Okonite Co., Passaic

New York

ABELS, ALOYSIUS J., President, A. J. Abels Co., Inc., Buffalo

BALDWIN, ARTHUR J., Publisher, Vice-President, McGraw-Hill Publishing Co., Inc., New York

CONNER, WILLIAM W., Engineer, Eastman Kodak Co., Rochester

CORLISS, WILLIAM J., State Locomotive Boiler Inspector, Public Service Commission, Albany

DIETER, WILLIAM, Torpedo Engineer, E. W. Bliss Co., Brooklyn

DIVINE, BRADFORD H., President, Divine Brothers Co., Utica

KEARFOOT, WILLIAM D., Marine Engineer, New York

LACY, ROBERT, Estimating Engineer, Otis Elevator Co., New York

MOEN, LECLANCHE, President, C. W. Hunt Co., Inc., New York

WATKINS, ARTHUR M., Secretary, Inter-Continental Machinery Corp., New York

North Carolina

HARDESTY, GEORGE H., Engineer in Charge, State Hospital, Goldsboro

Ohio

BICKETT, CHARLES A., President, The Bickett Machine & Mfg. Co., Cincinnati

CHRYST, WILLIAM A., Chief Engineer, Dayton Engineering Laboratories Co., Dayton

JUPP, ALFRED J., Sales Director, The Lunkenheimer Co., Cincinnati

LYON, GEORGE R., Vice-President, The Power Equipment Co., Toledo

STONE, JULIUS F., President, The Seagrave Co., Columbus

WALTER, FRANK L., Master Mechanic, Dayton Engineering Laboratories Co., Dayton

Pennsylvania

BRESSLER, J. WALTER, Metallurgist, Tacony Steel Co., Tacony

DUNN, J. JAY, General Superintendent, Shelby Steel Tube Co., Ellwood City

FORREST, JAMES, Assistant General Foreman, Baldwin Locomotive Works, Philadelphia

McNARY, JAMES E., Staff Engineer, Lubrication Division, The Texas Co., Pittsburg

SAYLOR, JOHN R., Proprietor, Pottstown Machine Co., Pottstown

SEVERS, Elmer B., Power Plant Engineer,
The United Gas Improvement Co., Philadelphia
WANDLESS, Franklin W., Tool Designing Supervisor,
Remington Arms Co., Eddystone

Tennessee

CAROTHERS, Charles G., Senior Mechanical Engineer,
Interstate Commerce Commission,
Division of Valuation, Chattanooga
DANIELS, Stanley H., Sales Manager,
Walsh & Weidner Boiler Co., Chattanooga

Wisconsin

MANIERRE, George, Proprietor,
Manierre Engineering & Machinery Co., Milwaukee
MILBRATH, Arthur F., Secretary and Engineer,
Wisconsin Motor Mfg. Co., Milwaukee
REVERE, Francis J., Assistant Engineer,
Allis-Chalmers Mfg. Co., West Allis

Canada

JOHNSON, Herbert, Assistant General Sales Manager,
Armstrong Whitworth of Canada, Ltd., Montreal
KINGSTON, James S., Heating and Ventilating Engineer,
Department of Public Works, Ottawa

Italy

FERRERO, Michele, President of
Società Italiana Macchine Utensili, Milano

Scotland

MITCHLEY, John W., Mechanical and Chemical Engineer,
Ministry of Munitions, Dornock, N. B.

FOR CONSIDERATION AS ASSOCIATE MEMBER OR JUNIOR

Alabama

ROBERTS, Arthur M., Assistant Superintendent,
Alice Furnace, Tennessee Coal, Iron & R. R. Co., Birmingham

California

LAMB, Hawthorne M., Senior Mechanical Engineer,
Interstate Commerce Commission, San Francisco

Illinois

DRAKE, Robert W., Steam and Electrical Engineer,
International Harvester Co. of N. J., Chicago
GOENSCH, Otto, Department Head,
Western Electric Co., Inc., Chicago
STUEBING, Albert F., Western Mechanical Editor,
Railway Age Gazette, Chicago
WHITESIDE, Victor, Testing Engineer,
Western Electric Co., Chicago

Massachusetts

PETRIE, Elmer H., Mechanical Engineer,
Fred T. Ley Co,. Inc., Springfield
WILKINSON, James, Consulting Engineer,
General Electric Co., Pittsfield

Montana

WOHLENBERG, Walter J., Assistant Professor of Mechanical
Engineering, University of Montana, Bozeman

New Jersey

STERN, Joseph H., Assistant Engineer,
Aeolian Co., Garwood

New York

BEINECKE, Fritz W., Supervisor of Automobile Equipment,
The Texas Co., New York
CHANDLER, Heman W., Draftsman Maintenance Department,
American Locomotive Co., Dunkirk
HILDRETH, Kenneth E., Chief Electrician,
New York & New England Cement & Lime Co., Hudson
HINRICHSEN, Arthur F., Works Manager,
Slocum, Avram & Slocum Laboratories, Inc., New York
LEACH, Edgar J., Engineer,
Curtiss Aeroplane & Motor Corp., Buffalo
LEISENRING, Frank S., President,
Mechanical Specialties Co., New York
RAMSEY, James F., Lubricating Engineer,
Vacuum Oil Co., New York
WACHENBERG, Lewis, Technical Assistant to Superintendent,
Arbuckle Bros., Brooklyn
WELSH, Milford G., Superintendent,
Mohawk Gas Co., Schenectady

North Carolina

SHEARER, David R., Consulting Engineer, Shulls Mills

Ohio

BRUSSEL, John W., Supervisor of Machining,
Dayton Engineering Laboratories Co., Dayton
HASKELL, Allan G., Sales Engineer,
Champion Spark Plug Co., Toledo

Oklahoma

WOOBANK, Wilfred, Sales Engineer,
Worthington Pump & Machinery Corp., Tulsa

Canada

BROOKS, Charles E., Superintendent Motive Power,
Grand Trunk Pacific Railway, Transcona, Manitoba
STEALEY, William G., Mechanical Superintendent,
British Cordite Co., Nobel, Ont.

FOR CONSIDERATION AS JUNIOR

California

BERG, Henning J., Engineering Department,
Standard Oil Co. of Cal., Corcoran
LILLA, Herbert L., Machinist's Mate, United States Navy,
U. S. S. Huntington, c/o Postmaster, San Francisco

Connecticut

BARNETT, Sydney A., Engineering Draftsman,
Hugh L. Thompson, Consulting Engineer, Waterbury

Illinois

STUERMAN, Robert V., Superintendent Heating Department,
Springfield Gas & Elec. Co., Springfield

Kentucky

SEATON, Edward W., Engineering Department,
Ashland Iron & Mining Co., Ashland

Maryland

LEDNUM, James M., Junior Engineer,
Davison Chemical Co., Curtis Bay
NELSON, Robert W., Foreman Shrapnel Shop,
Bartlett Hayward Co., Baltimore

Massachusetts

BAKER, Charles H., Jr., Member of Firm,
Norton Co., Worcester
BARRY, Edward H., Sales Engineer,
The Elliott Co., Boston
CHURCHILL, F. Loring, Instructor in Mechanic Arts & Drafting,
High School, Quincy

Michigan

COTTRELL, Holmes A., Carburetor Engineer,
Detroit Lubricator Co., Detroit
MOSES, Carl A., Insurance Engineering, Detroit

New Jersey

ILIFF, William L., Sales Engineer,
Hyatt Roller Bearing Co., Newark
RAUSCH, Roswell H., Engineer,
Niles-Bement-Pond Co., Plainfield
ROSS, Joseph M., Mechanical Engineer,
Thomas A. Edison, Inc., Silver Lake

New York

BUSHNELL, Burdge O., Mechanical Engineer,
New York Quebracho Extract Co., Brooklyn
DERRY, Gardner C., Sales Engineer, Rochester
ENGESSER, Benjamin M., Apprentice Engineer,
Pierce-Arrow Motor Car Co., Buffalo
MINOTTY, Joseph P., Mechanical Draftsman,
Combustion Engineering Corp., New York
MURPHY, Ambrose E.,
With Remington Typewriter Co., Ilion
OUTTERSON, Charles R., Sulphite Superintendent,
Carthage Sulphite Pulp & Paper Co., Carthage
WEBER, Robert L., Jr., Draftsman,
Combustion Engineering Corp., New York

Ohio

HODOUS, Louis W., Construction Supervisor,
The Canfield Oil Co., Cleveland
LANEY, Thomas G., Jr., Student, Lima

Pennsylvania

CARVIN, Frank D., Engineer of Tests,
Schaum & Uhlinger Co., Inc., Philadelphia
PARK, John F., Jr., with
Dodge Sales & Eng. Co., Philadelphia
WORTH, Paul, Mechanical Engineer,
Heine Safety Boiler Co., Phoenixville

Tennessee

LYLE, Alexander B., Superintendent,
Stickney & Montague Co., Chattanooga

Texas

BLAKESLEE, Walter A., Instructor in Mechanical Engineering,
Rice Institute, Houston

Washington

DONOVAN, Philip L., Purchasing Agent,
Bloedel Donovan Lumber Mills, Bellingham

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE MEMBER

New Jersey

KNIGHT, William, Assistant Mechanical Engineer,
Crocker-Wheeler Co., Ampere

Pennsylvania
MCGRAIL, FRANCIS J., Foundry Superintendent, Struthers-Wells Co., Warren
Canada
STENBOL, CARL, Superintendent Steel Department, Canada Cement Co., Montreal

PROMOTION FROM JUNIOR

Indiana
BARRETT, WALTER A., Mechanical Engineer, The Bass Foundry & Machine Co., Fort Wayne
Massachusetts
CARROLL, M. B., Commercial Engineer, General Electric Co., Lynn
New Jersey
ROYLE, VERNON E., Mechanical Engineer, John Royle & Sons, Paterson
New York
HORTON, CHARLES M., Industrial Writer, New York
Ohio
MANLEY, SUMNER M., Mechanical Engineer, The Proctor & Gamble Co., Ivorydale
MAROT, EDWARD H., Sales Engineer, Hyatt Roller Bearing Co., E. Cleveland
Tennessee
ALLEN, WHARTON H., Secretary-Treasurer, Allen-Scales Engineering Co., Nashville
South America
NELSON, ERNEST B., Assistant Engineer, Andes Copper Mining Co., Chanaral, Chile

SUMMARY

New applications	116
Applications for change of grading:	
Promotion from Associate-Member	3
Promotion from Junior	8
Total	127

NECROLOGY

ARTHUR BEARDSLEY

Arthur Beardsley was educated as a civil engineer at Rensselaer Polytechnic Institute, and was graduated in 1867 with the degree of Civil Engineer. Following his graduation, he was employed for one year as assistant engineer at the Hoosac Tunnel. In 1868, he entered private practice as a civil engineer and architect. In the following year, he was appointed instructor in civil engineering, physics and industrial mechanics at the University of Minnesota, and in 1870 was appointed to the chair of Civil Engineering and Industrial Mechanics at the University. In 1872, he was called to the chair of Mechanics and Engineering at Swarthmore College.

Mr. Beardsley was elected a life member of the Society in 1883, three years after its organization. He died on January 22, 1917.

J. ANSLEY HARTFORD

J. Ansley Hartford was born in Pittsburgh, Pa., on October 17, 1871. He received his early education in the public schools of Pittsburgh, and was graduated from the Pittsburgh Central High School at the age of 16. He served a four-years' apprenticeship as machinist at the Black Diamond Steel Works. He spent the next five years with the Westinghouse Electric and Manufacturing Co., entering as a machinist and being promoted through the tool-making division to the position of outside construction engineer, working on some of the largest power installations in the country.

In the meantime he had studied mechanical and electrical engineering at night, and was given charge of the electrical equipment of the Westinghouse Machine Company at East Pittsburgh. He remained at Pittsburgh eleven years in the capacity of factory engineer responsible for all service machinery. He designed the switchboard in use at the Pittsburgh plant. He represented the company in its joint betterment work with the Westinghouse Electric Co., organizing the Casino Technical Night School, Casino Restaurant and Library.

In 1910 he accepted the position of superintendent of design and manufacturing of the tractor works of the Smith Manufacturing Co., of Chicago. Later he designed the Breese motor plow and became secretary and general manager of the company organized to manufacture it. In February, 1916, he accepted the position of experimental and productive engineer with the Garford Motor Truck Co., which he held at the time of his death.

Mr. Hartford became an Associate of the Society in 1914. He died at Lima, Ohio, on March 17, 1917.

ALBERT C. STEBBINS

Albert C. Stebbins was born on September 19, 1845, in Monson, Mass., and received his education in the Monson Academy. When 19 years old, he came to New York City and worked for William Soules in the wool and flax business. Feeling the necessity of taking up a trade, he apprenticed himself as machinist with Lucius W. Pond, Worcester, Mass., from 1865 to 1870. In 1870 he went to New York as representative of Mr. Pond. Five years later, when the business changed hands and Mr. Pond's son, David W. Pond, took charge, Mr. Stebbins went back to Worcester as superintendent. In 1886, when the Pond Machine Tool Co. was established, Mr. Stebbins was made vice-president, and went to Plainfield, N. J., where he built the plant and had it running in the spring of 1888. In 1898, on the formation of the Niles-Bement-Pond Co., Mr. Stebbins was made vice-president and manager of the Pond works and continued in this capacity until the time of his death. He was also vice-president of the Pratt & Whitney Co., director of the Ridgway Machine Co. and vice-president of the Plainfield Savings Bank. He became a member of the Society in 1904. He died in Plainfield, N. J., February 28, 1917.

SILAS E. WEIR

Silas E. Weir was born on May 16, 1869, in Cookstown County, Tyrone, Ireland. He was educated at the Guilds Schools in London and served his apprenticeship with Coombe, Barboure and Coombe, Belfast, Ireland. Following this training, he went to British India to take charge of the installation and operation of a tea-drying plant located northwest of Calcutta. He had to give up this position, however, owing to illness, and he returned to Ireland for a period of about five years. He then came to the United States and worked for several firms—as general master mechanic with the Griffin Wheel Company, general superintendent with the Triumph Electric Company and works manager with the American Blower Company, retaining the last position until the time of his death. He became a member of the Society in 1914. He died in Detroit, on February 13, 1917.

WILLIAM C. WILLIAMSON

William C. Williamson was a member of the Society of long standing, having been elected to membership in 1882. He was a member of the firm of Williamson Bros. Company of Philadelphia. He died on February 12, 1916.

AMONG THE SECTIONS

THERE are several cities where the number of members of the Society is not as yet sufficient to warrant the establishment of a Section, but where a local organization exists which serves as a medium for bringing together the engineers of the locality. With the Section's reports will be listed in the future, therefore, reports of meetings of such organizations.

The Engineering Society of Nashville, Tenn., has opened its new headquarters at Room 409, Commercial Club Bldg., with secretary's office and technical reading room. The association holds a luncheon each Monday at 12.30 o'clock, with the exception of the first Monday of each month, when the meeting is held at 6.30 p. m., at which a set program is provided. Visiting engineers are always welcome at these events and at the association's quarters.

A Southwestern Society of Engineers has recently been formed at State College, New Mexico. This includes all branches of the profession. Until there are a greater number of engineers in any one branch than there are at present in a given locality, this organization will serve the purpose for which Sections in more thickly populated districts are established. The first convention was held on March 8, 9, and 10 and was a complete success. The papers presented would have done credit to the general meetings of some of the national societies.

ATLANTA

March 8. The Section was called to order for the election of officers for the ensuing year, and the following were elected: Oscar Elsas, chairman; Cecil P. Poole, secretary; Robert Gregg, J. N. C. Nesbit and Earl F. Scott.

Methods of interesting the members were discussed, and a trip was planned to the Atlantic Steel Co.'s plant. It was decided that such visits to industrial plants would be made periodically, and that at occasional meetings a paper prepared and read by one of the members would be the most effectual method of maintaining the interest of the members.

March 16. The Section visited the Atlantic Steel Company's works, and inspected with much interest the plant and equipment.

Earl F. Scott,
Section Chairman.

BIRMINGHAM

May 16. The Annual Meeting of the Birmingham Section will be addressed by Dr. Thornwell Haynes, President of Birmingham College.

April 11. This was one of the best meetings ever held by the Birmingham Section. It was addressed by Prof. M. Thomas Fullan, of Alabama Polytechnic Institute, on the subject of Technical Writing. Professor Fullan emphasized the fact that engineers should do more writing and the results would be profitable to both themselves and their readers. His clear and forceful description of the method of writing papers was much enjoyed and appreciated by his audience.

Paul Wright,
Section Secretary.

BOSTON

April 4 and 5. A two-day Joint Meeting of the Section and the American Institute of Electrical Engineers was held on these dates. The first session was held at the Engineers' Club on the evening of April 4. A buffet supper preceded the technical session, which was devoted to the general subject of Recent Developments in Steam Generation.

At this first session, Frederick Ewing presented a paper on Developments in Fuel Oil vs. Coal. This was followed by a paper on Up-to-Date Stoker Practice, by Sanford Riley, Mem.Am.Soc.M.E. High Pressures and Temperatures in a Modern Station was then discussed by I. E. Moultrop, Mem.Am.Soc.M.E. Prof. L. S. Marks, Mem.Am.Soc.M.E., reviewed the recent work of Messrs. Kreisinger, Ovitz and Augustine of the U. S. Bureau of Mines, on Combustion in Hand-Fired Boilers. The evening was closed by a paper entitled High Temperature Insulation of Boiler Settings, by P. A. Boeck.

The program for April 5 covered Isolated Plants and Central Stations, at the afternoon session, and Developments of Prime Movers, Condensers, Auxiliary Equipment, etc., at the evening session. Mr. Walter N. Polakov, Mem.Am.Soc.M.E., opened the afternoon session with a paper on Principal Factors in the Selection of Sources of Power. This was followed by a paper on Interesting Isolated Power Plants, by A. R. Meek, and by a second paper on An Isolated Power Plant in Connection with a Factory near Boston, read by William G. Starkweather, Mem.Am.Soc.M.E. Engineering Features and Results at the Holyoke Municipal Plant was presented by John J. Kirkpatrick, and W. F. Schaller closed the session with a paper on Coöperation between Isolated Plants and Central Stations, by Percival R. Moses and himself.

Following the afternoon session a dinner was served, at which brief addresses were made by several of the members and guests. Mr. Charles F. Weed, president of the Boston Chamber of Commerce, gave figures and statistics to show the almost incomprehensible amount of munitions being used in the war and compared this with the present quantity of munitions in this country. President Hollis outlined what the mechanical, electrical, civil and mining engineering societies are doing in assisting the Government to carry out its military and naval program. Prof. A. L. Williston, Mem.Am.Soc.M.E., and Dr. Frederick R. Hutton, Mem.Am.Soc.M.E., also spoke.

At the evening session, John A. Stevens, Mem.Am.Soc.M.E., gave a brief address upon the discussion of engineering subjects by engineering societies. R. A. Langworthy presented a paper on Engineering Features of Combined Heat and Power Distribution. Some remarks on turbine development in recent years were made by Dr. L. C. Loewenstein, Mem.Am.Soc.M.E., in the absence of Richard H. Rice, who was to read a paper on the Development of Steam Turbines. The meeting closed with a paper by Charles H. Bromley, entitled Recent Developments in Condensers and Modern High Vacuum.

William G. Starkweather,
Secretary.

BUFFALO

March 14. Before the Engineering Society of Buffalo, Karl W. Zimmerschied, of the General Motors Co., talked on the necessity of standardization as a measure of industrial preparedness, laying stress upon the standardization of detail. Mr. Zimmerschied said that efficiency is the great slogan of the times, but that it should be in evidence all along the line, as there is just as much efficiency in seeking facts which are of value and then utilizing them as there is in anything else. He also spoke of the adoption of the metric system, which he thinks is assured in machine-shop practice and engineering design, stating that the United States Government has recognized its value by adopting it in the aviation service.

April 4. Arthur S. Hurrell, superintendent of education in Indianapolis, Ind., spoke on Vocational Training, describing a survey prepared a short time ago which made clear the needs of industry and the wants of young men who proposed to enter mechanical occupations. He thought this would be of great value in the development of vocational education in other cities as well as Indianapolis.

Dr. George Smith, head of the Buffalo vocational-education department, and other educators commended the idea of the survey as a good thing for Buffalo and agreed that one of the needs in this city, if vocational training is to come into its greatest community influence, is public interest and support.

Louis J. Foley,
Assistant to Secretary.

CHICAGO

May 18. O. B. Zimmerman, Mem.Am.Soc.M.E., will present a paper on Small Internal Combustion Engines. The meeting will be held in the Hotel La Salle.

April 4. With an attendance of 125 at the regular dinner meeting, J. Philip Furbeck, of the Oxweld Railroad Service Co., gave a talk on Oxy-acetylene Welding. Mr. Furbeck limited his remarks to the practical application of oxy-acetylene welding in manufacturing, maintenance of equipment and machinery, reclamation work and the cutting of steel and wrought iron. A large number of lantern slides showed a great variety of work that had been done successfully at a cost considerably below that entailed by other methods.

This address was followed by a spirited discussion, joined in by a large number of those present. A nomination committee was selected, consisting of Messrs. C. C. Brooks, G. F. Gebhardt and Lewis M. Ellison, to present at the next meeting the names of candidates for the offices of the Section.

T. Wilson,
Corresponding Secretary.

MERIDEN

April 12. At the monthly meeting of the Meriden members E. P. Bullard, Mem.Am.Soc.M.E., president of the Bullard Machine Tool Company, gave a talk on the new Bullard employment plan which has been adopted by his company. Each person present at the meeting was given a pamphlet outlining the several branches of the plan, and Mr. Bullard then explained the workings in detail. He stated the workmen no longer asked for promotion or increased pay, as under the system this was taken care of automatically. A bonus is given if the men make full time all week, vouchers for this being paid after 30 days if the men are still in the company's employ, and a premium is paid for production above the standard amounts. The employees are insured without a medical examination. The workmen's welfare is looked after, and this is not confined to the shop, help being given in case of sickness in the home. Wages are higher under this system and the cost of production has been reduced, both workmen and company being benefited. Mr. Bullard said that while they were formerly much troubled with the constant loss of help, and the consequent necessity of breaking in new men, practically no such trouble exists under the new plan. In March only four men left the employ of the company out of something over 1,100 on the payroll. The company has an average of 1,500 applications for work per month and has closed its employment office.

C. K. Deckard,
Chairman.

MILWAUKEE

March 21. Capt. W. A. Moffat, U.S.N., commandant of the Navy Training Station at Great Lakes, Ill., addressed the Section.

Captain Moffat, who is an authority on naval matters, advocated the building of sea giants, volcanoes of power, by the United States, that would place the superdreadnoughts of foreign navies in the has-been class and would not necessitate the constant building of new ships. He considered it of little value to be continually building vessels which in a few years are out of date and go to the scrap-heap. The size of battleships, he said, should only be restricted by the limitations of the Panama Canal.

Capt. Moffat declared that a fleet of ships as large as it is possible to build would provide far greater protection and prestige to a nation than would a fleet of ships which are constantly being exceeded in size by those of other nations. He proposed ships of 60,000 tons displacement 250,000 hp., 995 ft. long and with a speed of 36 knots.

F. R. Dorner,
Section Secretary.

NEW ORLEANS

April 2. Preparedness was the subject of a paper by A. M. Lockett, Mem.Am.Soc.M.E., before the joint meeting of the Section and the New Orleans Association of Civil Engineers. The speaker told of the many and important ways in which the people of New Orleans may aid the nation in time of war, and his paper was discussed by Commodore V. S. Nelson, Major J. L. Schley, Major Richard C. Moore, Captain H. A. Drum, Lieut. Moses, General Perrillat and Prof. Williamson.

Mr. Lockett said that the United States was now in the position of a contractor who had been awarded a large contract and must assemble men, material and equipment to carry it to completion. The engineers and chemists of the country have already aided in this work by making an industrial inventory of equipment. He pointed out that a contractor having both skilled and common labor at work on a job would not set a mechanic to do the work of the water boy nor the common laborer to do the work of a mechanic, neither should the Government use the engineers for other work than that for which they are especially fitted, but should place each man where his knowledge would be most valuable.

In discussing the paper, Commodore Nelson spoke of the need of the Navy for more men, and explained what enlistment in the Navy and Naval Reserve entails and the different grades of service. He also pointed out the need of men on shore, such as radio operators, electricians, mechanics for machinery and ship-repair men for operating mine layers and mine sweepers, and the great need of men in the flying corps.

Major Schley said that the engineers were especially suited for the work of "apostles of preparedness," as they took a matter-of-fact view of things and knew something of the number of men and quantities of material required to accomplish large undertakings.

Major Moore, of the U. S. A. Engineer Corps, spoke of the need of both material and men. Satisfactory arrangements for the first have been made, but there is need of many men both in the ranks and as officers. Captain Drum, of General Pershing's staff, who has recently come here to create interest in the army training camp, described the object of training camps and the advisability of universal military training and service, as this would give us an army of men "whose interest is for peace, whose hopes are for peace and who will vote for peace with honor." He urged the citizens of Louisiana to attend the camp to be opened at Alexandria, and carefully explained the requirements for such attendance.

Lieutenant Moses, U. S. N., gave specific advice as to how the organizations in New Orleans could join in the work of aiding the Government, and suggested that the Association of Commerce establish and maintain a perpetual stock-card system showing material actually on hand and ready for immediate delivery to the Navy Yard, and that the merchants coöperate to develop a transportation system to insure this delivery. Suggestions were also made as to the facilities for motor-boat repair at the mouth of the river and the building of submarine chasers as well as plans for medical attention at that point.

General Perrillat pointed out that the country now has in hand a gigantic work, and cited Great Britain's mistake in taking men from the munitions factories for the front and then having to recall them. He considered it advisable to have a census of men made and their abilities listed. Professor Williamson followed with the same thought as to the census.

In conclusion, the President of the Louisiana Engineering Society was asked to appoint a committee to take up the work of making the roster of the members of the Society.

H. L. Hutson,
Section Secretary.

NEW YORK

May 8. Siegfried Rosenzweig, Mem.Am.Soc.M.E., will speak on The Development of the Poppet-Valve Steam Engine With Special Reference to Its Present Status in the United States.

April 10. The following Committee was elected to nominate officers for the coming year: George S. Humphrey, chairman, Philander Betts, F. R. Low, W. W. Macon and Edward Van Wrinkle.

Secretary Rice described in detail his trip to the various Sections which had taken him as far west as Oklahoma City. He also outlined the work which engineers are doing in the present crisis, and told the members present how best to offer their services to the Government.

The paper of the evening was presented by Earle Buckingham, Mem.Am.Soc.M.E., and was entitled Standards of Business Success. Mr. Buckingham said that we are living in an age of combinations

and mergers, and it has been rather generally assumed and asserted that there was no limit to the profitable increase of a business concern. He then presented accessible figures to show what happens to several departments of a concern when it very largely increases the amount of business transacted. For the purchasing department he showed that, in every line of business he had examined, the cost of materials showed an increase disproportionate to the growth of the business. He said that, from experience, a growing firm's sales costs would increase faster than the gross amount of business increases. In like manner there can be no question that the cost of credits will increase faster than the costs of the business. Cost of production involved labor and overhead charges and the complete showing of the production end of American business could not be ascertained at present.

A. D. Blake,
Section Secretary.

MINNESOTA

March 9. A banquet and entertainment was tendered Dr. Ira N. Hollis, President Am.Soc.M.E., at the Hotel Dyckman in Minneapolis. The guests present were addressed by Dr. Hollis, Dr. G. E. Vincent, President of the University, and Dr. Marion L. Burton, President-elect of the University. Dancing and a general get-together followed.

March 10. A symposium on steam locomotives was held at the Main Engineering Building of the University of Minnesota. Seven papers were read and many of them discussed, and an address was made by Dr. Hollis.

J. V. Martenis, Mem.Am.Soc.M.E., gave the opening paper, on Historical Development of the Locomotive. Locomotive Improvements, by Max Toltz, Mem.Am.Soc.M.E., was read by C. F. Shoop, Mem.Am.Soc.M.E. This was followed by Modern Methods of Locomotive Operation, by T. A. Foque, Mem.Am.Soc.M.E., and Historical Development of the Superheater on the Locomotive, by Geo. L. Bourne, Mem.Am.Soc.M.E., read by R. M. Ostermann, Mem.Am.Soc.M.E. A paper on the Use of Pulverized Fuel for Locomotives was read by J. E. Muhlfeld, Mem.Am.Soc.M.E., and papers on Economy of the Locomotive Superheater by R. M. Ostermann, and Feed Water Heating by George M. Basford, Mem.Am.Soc.M.E.

D. M. Forfar,
Section Secretary.

PHILADELPHIA

May 22. A joint meeting with the Engineers' Club and Affiliated Societies at Drexel Institute will be addressed by Willard Behan on Engineering of Men.

March 27. A joint meeting of this Section and the Philadelphia Chapter of the American Society of Heating and Ventilating Engineers was addressed by Walter J. Kline, of the American District Steam Heating Co., on District Heating.

Mr. Kline gave much thought to the design and financing of various systems, emphasizing the desirability both from the producers' and consumers' standpoint of the installation and use of meters.

March 30. The Engineers' Club of Philadelphia celebrated its fortieth anniversary by a banquet at the Bellevue Stratford Hotel. Patriotism and loyalty were the keynotes of the evening, and much was said of the part played by the engineer in construction and destruction in time of war.

References to salient points in the history of the Club were made. The Club was organized in December, 1877, with nineteen members, at whose residences the meetings were held for the first few months, after which the Club opened its own headquarters. After several changes it took possession of its present quarters at 1317 Spruce Street in 1907. Among receptions tendered by the Club to visiting engineers and engineering societies were one to Count Ferdinand de Lesseps in 1880, and one to the delegates from the Society of Engineers of France to the Chicago World's Fair in August 1893.

Following proceedings inaugurated in 1913, affiliation was effected in 1915 between the Club and the Philadelphia Sections of the American Institute of Electrical Engineers, The American Society of Mechanical Engineers, American Society of Civil Engineers, Illuminating Engineers, Technology Club of Philadelphia, Massachusetts Institute of Technology, Society of Automobile Engineers and American Society of Heating and Ventilating Engineers.

By a whirlwind campaign in the latter part of 1915, the club membership was increased within a few days from 524 to 2336, an increase of nearly 350 per cent.

W. R. Jones,
Section Secretary.

PROVIDENCE

May 21. Subject: Time and Motion Study.

February 28. An open meeting to which ladies were invited was addressed by M. R. Hutchison, Mem.Am.Soc.M.E., engineering advisor to Thomas A. Edison and a member of the Naval Consulting Board, on Edison, His Life and Achievements. Mr. Hutchison illustrated his lecture with lantern slides and moving pictures of interest.

March 28. The Providence Engineering Society held a very largely attended meeting, at which Dr. Ira N. Hollis, President Am.Soc.M.E., George H. Pegram, President Am.Soc.C.E., and Harold W. Buck, President Am.Inst.E.E., spoke on The Engineer and Organization.

Dr. Hollis pointed out the relations between the engineer and democracy, dwelling on the fact that the spread of democracy seems to have run parallel with the growth in engineering achievements from the time of James Watt, inventor of the steam engine, down to the present. The speaker said that it was the duty of engineers to stand for the principles of democracy and use their influence to have trained men picked for high offices in the government: and in order to do this the coöperation of engineers throughout the land is necessary.

Mr. Buck dwelt on the fact that all engineering problems are coöperative, and asked for coöperation between the engineer and the scientist, instancing Faraday's work which a century ago was looked upon by engineers as fanciful and pretty but which today forms the basis of great electrical attainments.

Mr. Pegram suggested that if our Government had a department of public works there might be improvement in the handling of many problems. The Government has but recently officially recognized the engineer, but without his services it is doubtful how much progress could be made.

Following these addresses General Abbot, of the Rhode Island National Guard, spoke on coöperative work among the engineers necessary in time of war. Dr. Faunce, of Brown University, also emphasized the necessity for coöperation, and Major Buxton, of the National Guard, advocated compulsory military training.

A. E. Thornley,
Corresponding Secretary.

ST. LOUIS

The St. Louis Section sends in a description of the organization and work of the Engineers' Club of St. Louis, which, in its reincorporated form, includes the Club and the Local Sections of the National Societies of Civil, Mechanical and Electrical Engineers and of the American Society of Electrical Contractors. The description was given in a recent paper by Mr. F. G. Jonah, presented before the third conference on Engineering Coöperation.

The Club maintains permanent quarters, containing the office of a secretary, who devotes his whole time to Club affairs, a fairly good reference library, a reading room supplied with all the technical journals, and an auditorium equipped with a motion-picture machine.

Meetings are held weekly during the season and papers for presentation are arranged for by the various Sections in turn. The Club publishes a bi-monthly journal in which papers and discussions are printed, and issues a bulletin monthly, devoted to general news.

The Club has attempted in a dignified manner to influence the solution of public questions involving engineering and scientific consideration and maintains, among others, the following standing committees: Civic, City Plan, City Building Code, Quantity Surveying, and Good Roads. These committees watch legislation in city and state, and are frequently requested to coöperate with the municipal authorities.

STUDENT BRANCHES

Members of Student Branches are requested to notify the Secretary of any change in address as promptly as possible, in order to facilitate delivery of The Journal.

The University of Cincinnati Student Branch extends an invitation to the Student Sections in the vicinity of Cincinnati to visit that city at the time of the Spring Meeting of the Society during the week of May 21. This, the Semi-Annual Meeting of the Society, offers to Student Members the opportunity to become better acquainted with the manner of conducting the work of the Society. Students are invited to attend the professional sessions and hear the discussions of engineering problems of the day.

One of the important features of the Spring Meeting will be the visits to industrial plants, of which there are a number in Cincinnati. Invitations will be extended to Student Members to accompany the parties on the various trips of inspection arranged to these plants, and also to the places of interest scheduled on the program, and in all probability students will be invited to attend the social affairs.

Plans are well under way for a big Joint Meeting of the Student Branches to be held at the University of Cincinnati. It is hoped that a goodly number will go to Cincinnati, and that this Joint Meeting of Student Sections will be a record breaker. This meeting will afford an excellent opportunity for the men from the colleges to become acquainted. The University of Cincinnati men are looking forward to this Joint Meeting with a great deal of anticipation.

On April 13, a convention of Student Members was held at the Engineering Societies' Building, New York, and delegates of the following branches participated: Columbia University, Lehigh University, New York University, Polytechnic Institute of Brooklyn, Rensselaer Polytechnic Institute, Stevens Institute of Technology and Syracuse University.

The meeting was divided into two sessions, the first of which was addressed by Prof. Lionel S. Marks, Mem.Am.Soc. M.E., on The Explosion Process in Gas Engines, by Prof. Arthur M. Greene, Jr., Mem.Am.Soc.M.E., on Pumping Engines, and Prof. Charles E. Lucke, Mem.Am.Soc.M.E., on Surface Combustion. Prof. F. R. Hutton, Mem.Am.Soc.M.E., opened the meeting with an introductory address in which he outlined the rapid development of the Student Branches of the Society, and spoke of the great benefit derived from joint meetings of branches.

Following the professional session, those present were shown through the Engineering Societies' Building, after which supper was served. In the evening a Smoker was held, at which Mr. "Jack" Armour, of *Power,* entertained and made a decided hit. All present joined in patriotic and college songs and Prof. William Kent, Mem.Am.Soc.M.E., spoke on the opening days of the war and compared them with the days of '61. A collation closed the meeting.

The Committee on Student Branches consists of Frederick R. Hutton, chairman, George M. Brill, William Kent and George A. Orrok; and John L. Kretzmer and James G. Manning, of Columbia, George H. Hauser, Jr., and Joseph Gilman, of N. Y. U., Arthur A. Bielek, chairman, and Frank R. Stamer of Poly, and Sprague Hazard and Alvin G. Searles of Stevens formed the committee on arrangements for the joint meeting.

ARMOUR INSTITUTE OF TECHNOLOGY

March 14. Mr. S. W. Thal gave an elaborate illustrated lecture on Automobile Ignition, followed by G. M. Fritze with a short talk on Walter Tractors.

March 28. After the regular business Mr. Taylor gave a talk on Thermit Welding, R. E. Marks spoke on Motion Pictures and G. M. Fritze discussed Trackless Trains thoroughly and in an interesting manner.

April 1. G. W. Jewell, of the Builders Iron Foundry, gave an illustrated lecture on the Venturi Meter, Its History, Development and Uses. The lecture was followed by discussion.

Abe J. Plocinsky,
Branch Secretary.

BUCKNELL UNIVERSITY

April 9. This was the first meeting of the Spring Term, and C. D. Maurer, '17, gave an instructive talk on Power Plants, in which he described the equipment of the Shamokin Power Plant.

He was followed by Prof. F. E. Burpee, Mem.Am.Soc.M.E., who spoke on the Engineer Officers' Reserve Corps, and announced that he had offered the services of himself and the graduating class to the War Department.

C. M. Kriner,
Branch Secretary.

CASE SCHOOL OF APPLIED SCIENCE

April 10. Advertising was the subject of an address by C. H. Henderson, of the Cleveland Twist Drill Co. The talk was full of snap, and contained much advice for the young engineer in business.

Alexander Trenhoft,
Branch Secretary.

UNIVERSITY OF CALIFORNIA

March 24. The banquet held jointly with the Student Branch at Leland Stanford University was a great success. After many interesting addresses and excellent music, a number of the members of this Branch attended a theatre party.

April 3. William A. Doble, Mem.Am.Soc.M.E., read an interesting paper on the new Doble steam engine for automobiles, pointing out the principles upon which it is based. It was of timely interest and was much appreciated.

John H. Fenton,
Branch Secretary.

CARNEGIE INSTITUTE OF TECHNOLOGY

March 21. W. O. Renkine, who is connected with A. M. Byers Co., addressed the Branch on the subject of powdered coal.

Mr. Renkine said that although powdered coal as a fuel had been experimented with as far back as a hundred years ago, the first practical application of it was not made until 1894 and was monopolized by the cement industry. Due to the high cost of oil and scarcity of natural gas it was found necessary, about two years ago, to experiment with powdered coal in the production of iron and steel.

In his talk Mr. Renkine described the various stages of pulverizing, storing and burning powdered coal, and the obstacles met with during the experimental development of the processes.

James H. Davis,
Branch Secretary.

UNIVERSITY OF CINCINNATI

March 23. An interesting talk was given by Calvin W. Rice, Secretary Am.Soc.M.E., on the work that engineering societies are doing for the nation in regard to national defense. He described the formation of the Naval Advisory Board, the Munitions Standardization Committee and the Committee on Industrial Preparedness. He advised all students to participate in all student activities and to strive for responsible positions on committees that serve the business world. He also urged the students to make use of the free service of the Engineering Societies' Library.

March 30. E. A. Muller, Mem.Am.Soc.M.E., devoted part of a talk to the problems confronting a newly organized concern in the machine-tool industry, explaining systems for numbering parts and for routing work throughout the shop. This was followed by a discussion of bonus and premium systems and employment problems. The remainder of the talk was devoted to the design of new factories and alterations on old buildings. Location, light, sanitation and pleasant surroundings were mentioned as requisites for a satisfied working force.

HENRY A. WOLSDORF,
Branch Secretary.

COLORADO AGRICULTURAL COLLEGE

March 23. A lengthy discussion regarding the process of manufacture of ball bearings was given by Prof. L. D. Crain, Mem.Am. Soc.M.E. The talk was well illustrated with slides from the S. K. F. Ball Bearing Co., and chief topics of the discussion were the various operations of manufacture, kinds of material used and the extensive application of ball bearings.

E. C. JOHNSON,
Branch Secretary.

UNIVERSITY OF COLORADO

April 10. At the regular meeting of the Branch, Prof. J. A. Hunter, Mem.Am.Soc.M.E., reported on the convention of the oil men called by the U. S. Bureau of Standards, at Washington, D. C., for the purpose of establishing standards by which gasoline and oils might be more uniformly classified. His report was supplemented by a description of the oil-testing equipment used in the Bureau, and a discussion followed.

W. S. BEATTIE,
Branch Secretary.

COLUMBIA UNIVERSITY

February 28. The United Engineering Societies of Columbia University were addressed by Charles Ferguson, who had accompanied Colonel House on a trip through Europe, and who, on his return, presented a report on industrial conditions there to President Wilson.

Mr. Ferguson said that he considered the engineer to be the dominant factor in the future regulation of society, and emphasized the importance of the engineers' viewpoint on vital matters. He said that those who conquered in the struggle of business competition would be better fitted to control the workings of the state than any other group of men, and the engineer is the man to develop the great business system to its fullest measure.

JOHN L. KRETZMER,
Branch Chairman.

CORNELL UNIVERSITY

March 26. What is a Ship was the subject of an address by Prof. G. R. McDermott, naval architect and head of the ship-design department of Sibley College.

Professor McDermott pointed out that the developments of the modern day have made it necessary to include in the name *ship* airships and submarines. He explained the advantages of each of the different classes of ships. He described the problems of building and launching, and called attention to the fact that every branch of engineering is made use of in the construction of all vessels.

S. M. BARR,
Branch Secretary.

STATE UNIVERSITY OF IOWA

March 29. F. M. Kolar gave a talk on High Speed Steel, dealing with the annealing, hardening and tempering of it.

C. L. SEVERIN,
Branch Secretary.

UNIVERSITY OF KANSAS

April 3. The Ninth Annual Meeting of the Branch was held in three sessions, with Dean P. F. Walker, Mem.Am.Soc.M.E., H. A. Fitch, W. C. Baxter, Mem.Am.Soc.M.E., Calvin W. Rice, Secretary Am.Soc.M.E., A. Hurlburt, Mem.Am.Soc.M.E., R. A. Rutledge and W. W. Walford as the speakers.

As a departure from the usual program, three illustrated lectures were given by S. K. F. Co., on the Present-Day Application of Ball Bearings; by the Lodge and Shipley Machine Tool Company, on the Manufacture and Testing of Lathes, and by the National Tube Co., entitled From Ore to Finished National Pipe, respectively. Dean Walker made the opening remarks, and Mr. Fitch spoke on Industrial Development in the Southwest. Mr. Baxter, who is connected with the Wichita Pipe Line Co., discussed Natural Gas Engineering, and he was followed by Mr. Rice, who spoke on the Engineer in Public Service. Mr. Hurlburt's topic was Engineering in Public Utilities.

At the afternoon session and the banquet in the evening Mr. Rutledge, Chief Engineer of the Santa Fé Railroad, gave an address on Qualifications for an Engineer, and Mr. Walford, head of the advertising department of this road, addressed the Branch on A Tour Through the Southwest.

April 12. Mr. L. H. Chase, head of the farm-machinery department, gave a very interesting talk on Agricultural Engineering and Its Importance.

HARLAN A. RUSSELL,
Branch Secretary.

STATE UNIVERSITY OF KENTUCKY

March 17. The Branch was most fortunate in securing Samuel Rea, President of the Pennsylvania Railroad, to speak at its meeting.

Mr. Rea related in an informal way some of the tremendous problems involved in operating the great system of which he is head, discussing these problems from both financial and engineering standpoints. He referred to the expansion of the system, telling how it was found necessary to build the two tunnels under the Hudson River between New York and New Jersey in order to meet the conditions of growing traffic.

By way of advice to the students present, he said that the man without a technical education cannot hope to compete in the field of engineering or other professions requiring technical knowledge with one having the advantages of such a training. He considered conditions in the profession were now more exacting than when he entered it, and stated that although he himself had been charged with supervisory responsibility for more than nine years he would not undertake the engineering details of some of the works which the Pennsylvania Railroad had undertaken in its tunnel construction.

April 8 to 15. Prof. F. Paul Anderson, Mem.Am.Soc.M.E., and Prof. W. E. Freeman, conducted the senior class on an inspection trip to Chicago and vicinity. The party paid visits every day to various industrial plants and points of interest.

D. S. SPRINGER,
Branch Secretary.

LEHIGH UNIVERSITY

March 22. W. P. Berg, '17, and H. E. Kantner, '17, were the speakers. Mr. Berg gave a talk on the Manufacture of Paper from Wood Pulp, describing how the paper is prepared from chemically treated wood pulp, obtained from the wood either by the soda or bisulphate process, and so on through the various stages to the finished product. Mr. Kantner spoke on Present-Day Applications of Ball Bearings, bringing out the points in their manufacture, design and uses by means of a large number of lantern slides.

F. M. PORTER,
Branch Secretary.

LELAND STANFORD JR. UNIVERSITY

March 24. The Branch joined with the University of California Branch in a banquet at the Engineers' Club of San Francisco. Dr. W. F. Durand, Mem.Am.Soc.M.E., acted as toastmaster, introducing as speakers W. K. Potts, C. E. Grunsky, Prof. H. B. Langille, Mem.Am.Soc.M.E. and G. W. Dickie, Mem.Am.Soc.M.E. The evening was greatly enjoyed by those present, and it is hoped to make this an annual event of the two Branches.

The form of program was somewhat original, showing a curve

on which the readings indicated the periods during the evening at which the various entertainment features would take place.

A. L. Morgan,
Branch Secretary.

LOUISIANA STATE UNIVERSITY

March 14. E. C. Freeland read a paper on Burning Bagasse, in which he compared the fiber content of the cane at various stages of the process of sugar manufacture. He illustrated the processes of burning bagasse.

J. A. Nadler,
Branch Secretary.

RENSSELAER POLYTECHNIC INSTITUTE

March 5. Dr. Ira N. Hollis, President Am.Soc.M.E., spoke on The Engineer and the National Crisis. Dr. Hollis, referring to the adage that "history repeats itself," gave illustrations in the present events; he also described what he considered efficiency and the attitude of the people toward the government, impressing upon the minds of those present that it was the duty of the engineer to increase the efficiency of the government.

H. M. Hammond,
Branch Secretary.

SYRACUSE UNIVERSITY

It has been the practice of the Student Branch to have as many good talks as possible given by men experienced in the engineering field at their meetings held every other week, and a debate between the mechanical and electrical Student Branches was a feature of the year.

R. M. Milford,
Branch Secretary.

UNIVERSITY OF MAINE

March 21. N. A. Robbins, Mem.Am.Soc.M.E., chief engineer of the Orono Pulp and Paper Co., outlined the growth of the power plant of this company and described the problems which have come up for solution in connection with it from time to time. The plant is a modern one in every way and furnishes a good example of an up-to-date power plant in a present-day manufacturing establishment.

R. E. Fraser,
Branch Secretary.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

March 23. John A. Stevens, Mem.Am.Soc.M.E., was the speaker at the smoker held by the Branch on this date. Mr. Stevens spoke of the value of the man to the company employing him and related many of his sea experiences while chief engineer of the S.S. St. Paul. K. C. Richmond, '16, spoke on Rock Tunnel Construction, describing the machinery used and stages in the work.

March 30. Patent Law was the subject of an address by a member of the class of '88, Odin Roberts, Mem.Am.Soc.M.E., a prominent patent attorney. Mr. Roberts gave examples illustrating the salient points of our patent law as it stands today.

E. P. Warner, '17, followed with a talk on The Stresses Developed in Aerial Propellers, illustrating his talk with plots and diagrams and a full-sized propeller to show sections and angles.

May 6. J. A. Moyer, Mem.Am.Soc.M.E., spoke on Steam and Gas Tnrbines, illustrating his talk with lantern slides. The speaker answered many questions about both types of turbines, materials used, efficiencies, etc. H. M. Brayton, '17, spoke on Engineering Charts.

Edward W. Rounds,
Branch Secretary.

NEW YORK UNIVERSITY

It was decided to replace the April meeting by the courses given especially for mechanical engineers at the Brooklyn Navy Yard. Passes were obtained for each member, and instruction was given on board the U.S.S. New Jersey under the supervision of a lieutenant detailed on this ship. Three courses were being given, Ordnance and Gunnery, Electrical and Steam Engineering, and Signaling and Navigation, but with the declaration of war these were discontinued. However, a course of signaling is being established at the University under the supervision of Prof. C. P. Bliss, and it is expected that most of the members will attend.

Joseph Gilman,
Branch Secretary.

OHIO STATE UNIVERSITY

March 21. Prof. John R. Allen, Mem.Am.Soc.M.E., gave an interesting lecture on Engineering in Turkey, in which he described the manner in which construction work is done there and the difficulties encountered. He urged the engineers to become proficient in foreign languages, as it is impossible to do an export business in one language. He stated that the American exporter through his shortsightedness, loses his greatest opportunity in the line of raw materials, by having to sell his goods through European salesmen who are able to speak the required language.

F. E. Smyser,
Branch Secretary.

OREGON STATE AGRICULTURAL COLLEGE

Mrch 15. Mr. Graf described the interesting things seen by him on his trip East. Mr. Goldman read a paper on The Engineer in Practice, in which he called attention to the opportunities open to the engineer.

April 5. After the transaction of the regular business, Mr. Peaslee gave an informal talk on the Engineer Officers' Reserve Corps and the Opportunity in It for Engineers, and Mr. Orr gave an informal talk on Plant Operation.

Arthur O. Leech,
Branch Secretary.

UNIVERSITY OF PITTSBURGH

April 12. Mr. Goldberg read a paper on the Uniflow Engine, treating of its economy, problems of design and development. The paper was discussed by Messrs. Noss and Lynch. At this meeting plans were talked over regarding the part to be taken by engineers in the Preparedness movement.

March 15. Mr. Hutcheson read a paper on Superheaters, which dealt with the progress and history of superheated steam. The paper was discussed by Mr. Wachter and Mr. Russo.

F. C. Noss,
Branch Secretary.

PURDUE UNIVERSITY

March 15. Mr. Hannun, of the mechanical department, spoke on the uniflow steam engine. His discussion dealt primarily with the type of uniflow engine manufactured by the Skinner Engine Co., with which he was formerly connected, and with the Stumpf engine.

March 27. Prof. L. W. Wallace, Mem.Am.Soc.M.E., talked along the lines of locomotive engineering, devoting special attention to the advantages of the superheater engine over that using saturated steam. The talk was based upon data derived from tests in the Purdue Locomotive Laboratory and that of the Pennsylvania Railroad, and was illustrated with many photographs.

W. G. Schutt,
Branch Secretary.

THROOP COLLEGE

March 5. A most successful joint meeting of the mechanical and electrical Student Branches was held, with Earl Ovington as the speaker.

Mr. Ovington, who is a pioneer in aviation, being the first man to fly a monoplane in the United States and the winner of several big races in exhibition flying, held the attention of his audience with descriptions of his wide experiences which he illustrated with lantern slides.

Reginald Coles,
Branch Secretary.

VIRGINIA POLYTECHNIC INSTITUTE

April 2. The King of the Rails was the subject of a motion picture of much interest. The film was furnished through the courtesy of the General Electric Co.

April 10. G. F. Minor gave an interesting lecture on the Pelton Water Wheel, which was illustrated with slides supplied by The Pelton Water Wheel Co.

G. F. MINOR,
Branch Secretary.

UNIVERSITY OF WASHINGTON

March 9. The Branch held a meeting in Engineering Hall, when the object of the organization was outlined and plans for future meetings and trips were formulated. The following officers were elected: Chairman, Philip G. Johnson; Secretary, Claire L. Egtvedt, and Treasurer, Thomas P. Evans.

March 22. The accurate determination of secondary stresses in complicated steel castings, particularly truck frames and body bolsters of freight cars, was the subject of the lecture before the Branch by George B. Floyd, of the American Steel Foundry Co., of Chicago.

Mr. Floyd recited the advantages of the Berry extensometer in the determination of the weak parts in castings, and described in detail, with the aid of blue prints, the results of extensive experiments conducted by his company with this apparatus.

WALTER HENRY KURTZ,
Branch Secretary.

UNIVERSITY OF WISCONSIN

March 15. At the regular semi-monthly meeting of the Branch, A. G. Hoppe presented a paper on Advertising, in which he dealt with fake advertisements of an engineering nature found in non-technical journals, using an example from a current magazine.

March 26. The first annual banquet was held, with Calvin W. Rice, Secretary Am.Soc.M.E., as the guest of honor; Prof. G. L. Larson, Mem.Am.Soc.M.E., as toastmaster, Dean F. E. Turneaure and Prof. J. G. Callan as speakers.

As his message to the Branch, Dean Turneaure emphasized the value of Outside Activities for the Student and the Engineer. Mr. Rice urged the technical student to consider how he could best serve his country in the present crisis, suggesting that the trained man should not rush into private enlistment but hold himself in readiness to be placed where he can do the greatest amount of good. Professor Callan spoke upon the Broader Engineering Education, and commended the present tendency of engineering schools to broaden their training by the addition of cultural courses. A. E. Kelty, president of the Branch, gave the response.

March 29. Mr. Grant described the various methods he had tried in analyzing the vibration of an automobile engine. Magazine reviews were given by J. M. Wood, on the manufacture of steel balls; Mr. Roberts on the characteristics of the 1917 automobile, and Mr. Seelbach on the conference of motor-boat manufacturers with Secretary Daniels regarding small speed power boats for the Navy.

JOHN M. WOOD,
Branch Secretary.

EMPLOYMENT BULLETIN

THE SECRETARY considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, by putting them in touch with special opportunities for which their training and experience qualify them, and for helping anyone desiring engineering services. The Society acts only as a clearing house in these matters.

POSITIONS AVAILABLE

In forwarding applications, stamps should be enclosed for transmittal to advertisers; applications from non-members should be accompanied by a letter of reference or introduction from a member, such reference letter to be filed with the Society. Copy for notices must be in hand by the 15th of the month.

ESTIMATOR. Plant in Western New York manufacturing steel-plate tanks and receptacles, desires the services of estimator. In first letter state age, experience, training, single or married, salary, present employment. 634.

HEATING AND VENTILATING ENGINEER, young technical graduate, three or four years' experience. Location Ohio. 665.

SUPERINTENDENT for automobile-tire factory, man who understands compounding, and knows machinery and installation. Location Minnesota. 666.

PLANNING DEPARTMENT AND TIME-STUDY MEN. Well-established firm offers exceptional opportunities for effective and interesting work to engineering graduates with substantial experience with modern industrial accounting with special reference to time study, determination of standard tasks and planning and scheduling production. State age, education, experience, present and expected salary. 679.

DRAFTSMEN, experienced, preferably not over 30. Permanent employment and advancement to capable men. 751.

POWER ENGINEER for large industrial corporation operating own steam and electrical power plants. Young man with executive ability, mechanical or electrical-engineering graduate, experienced in power plant and power distribution, design, and operation. State age, school, year of graduation, detailed experience, salary expected. Location Michigan. 763.

PRODUCTION MANAGER, 30 to 40, married preferred, clean-cut, aggressive, of generous build. Technical graduate preferred. Must have had practical experience in every branch, such as shop work, drawing-room work, tool designing; must also have had successful experience of at least five years; must be thoroughly informed in modern cost and planning-department methods. Electrical manufacturing experience preferred, though not absolutely essential. Location vicinity of New York. Salary $3,000 to $4,000. 890.

ENGINEER for clock company in New England. Experience in handling men, up to 500, engaged in manufacture of woodworking parts from raw timber through to highly finished exterior, and supervising of numerous small parts in clocks. Must be capable of improving quality and increase output. 917.

THREE DRAFTSMEN, pipe work; steam, hydraulic, water, and air piping. Also MACHINE DESIGNERS and plant layout men. Also first-class STRUCTURAL STEEL and POWER-PLANT man. Location Ohio. 927.

DRAFTSMAN familiar with valve detail and design and experienced in estimating and layout work. Excellent opportunity for competent man. State age, experience in detail, references and salary expected. Location New York State. 928.

RECENT TECHNICAL GRADUATES for shop positions with company manufacturing recording meters, with opportunity to advance in other lines of work as business expands. Location Boston. 933.

YOUNG TECHNICAL GRADUATE with one or two years' experience in steam engineering, for testing work. Location New Jersey. State age, experience and salary expected. 939.

INSPECTOR, experienced in expediting machinery deliveries. Giving particulars, experience, etc. 942.

DRAFTSMAN on design of new machinery, equipment, general work in connection with plants of a steel and wire company. 945. American Steel & Wire Co., Mr. P. Morrison, Ch. Draftsman, Trenton, N. J. Telephone 3225.

THREE HIGH-GRADE ENGINEERS, thoroughly conversant with application of all phases of production and cost work, able to carry through alone handling of contracts. Essential qualifications, pro-

nounced power of observation and analysis, ability to plan and organize, practical type of mind, tact and sound judgment in dealing with clients. Headquarters New York. 946.

FACTORY ENGINEER, technical graduate, with successful record as assistant superintendent or superintendent for concern manufacturing polishing and buffing wheels, and employing 150. Must be conversant with scientific management and able to secure, retain and handle successfully both men and women. Give age, experience, education, and salary expected. Permanent position with splendid future for right party. 948.

DRAFTSMAN experienced in factory design and installation of elevator and conveying machinery in general cement-plant work. Location Pennsylvania. 949.

RECENT ENGINEERING GRADUATE to take up economy studies in pole-line and cable-plant construction. Man having some experience in estimating cost of such construction given preference. State experience and salary desired. New York. 952.

MAN to run COST OFFICE. One with practical machine-shop experience, and who understands theory of cost accounting, and has had experience in instructing clerks. Employ about 475 in diversified work with foundry, pattern and machine shop. Salary $25 a week. Location Massachusetts. 953.

ENGINEER. Young technical graduate to engineer, design and take charge of production of electro-mechanical devices, and to conduct performance tests on standard and special designs. Salary to start $100. Location Middle-West. 954.

CHIEF ENGINEER for industrial power plant operating 10,000 boiler hp. and 5,000 electrical. Must be well up on combustion and plant maintenance. State salary. Location North Carolina. 956.

ENGINEER on design and experimental work. Good personality. Salary to start $1200. Location Elizabeth, N. J. 957.

COMPANY with factory in western Maryland desires man with technical training, in the capacity of assistant designer and works manager. To assist in designing special machinery and developing ideas; analyze machine operations, prescribe equipment and devise means to effect speedy and economical production; superintend manufacturing such machinery. Requires ability of thoroughly practical master mechanic with original ideas as to methods, knowledge of modern shop practice, familiarity with design and application of time-saving fixtures, executive ability and diplomacy necessary to successfully direct manufacturing plant. No question of salary if right man applies. In first letter state full particulars and experience from technical degree which will be held confidential. 958.

SALESMAN, steam power-plant specialties. College graduate preferred, and, if possible, having experience in similar line of work in Philadelphia. Should be capable of taking charge of office eventually. 959.

DRAFTSMEN (three or four) experienced in plant layouts and special-machinery design. 963.

PRODUCTION ENGINEER to take charge of cost-reduction work in Canadian shop manufacturing air compressors, rock drills. State age, experience and salary expected. 974.

INDUSTRIAL PLANT ENGINEER. Mechanical engineer, preferably college graduate, with several years' all-round experience which would fit him to take charge of design, construction and maintenance of factory buildings and equipment. Good opportunity with large growing company, desirably situated. Location New York. 977.

PRODUCTION ENGINEER, must have thorough factory experience on motor-truck construction, organization, production, equipment and accounting. Live wire. State age, experience and salary desired. 988.

DRAFTSMAN, technical graduate, familiar with design of power-station installations, steam piping and fair amount of structural work. State age and experience. Location Brooklyn, N. Y. 990.

MECHANICAL ENGINEER having had technical education and at least five years' experience in plants manufacturing chemicals. Work mainly advisory engineering work in connection with manufacture of chemicals. Address, E. I. duPont de Nemours & Company, Engineering Department, Wilmington, Del. 991.

DRAFTSMAN wanted immediately by Chicago rubber works. Ingenuity is prime requisite. To work from rough sketches of labor-saving appliances. Permanent. Salary $25 for six months, $35 for next six months, future advances contingent on ability. Describe physical condition and education, state months on previous jobs and approximate hours per month in each kind of duty. 992.

MEN AVAILABLE

Only members of the Society are listed in the published notices in this section. Copy for notices should be in hand by the 15th of the month, and the form of the notice should be such that the initial words indicate the classification. Notices are not repeated in consecutive issues.

ENGINEER desires position in connection with maintenance or production of railway rolling stock and equipment or production incident to national defense. At present employed. Twenty years' experience in design and construction of industrial and railway mechanical equipment. Highly specialized in practical application of applied science, locomotives, cars, trucks, boilers, engines, turbines, tanks and special machinery, shop layouts and power plants, towers and structural work. E-158

MECHANICAL ENGINEER, 27, at present employed as assistant master mechanic with large packing company. Experienced in power-house design and layouts with refrigerating machines and steam plant; also general packing-house building, machine repairs and layouts. E-159

MECHANICAL ENGINEER, 30, M. E. graduate, practical shop, power-plant, drafting, plant maintenance, and production experience. Desires position in engineering, estimating, or maintenance department of reliable concern. Location immaterial. E-160

STUDENT MEMBER, 22, will graduate in June in mechanical engineering, University of Michigan. Desires position as assistant to chief engineer, production manager, or superintendent for manufacturing concern, preferably Ohio or Michigan. Has had experience in drafting and office work. Will furnish references. E-161

MECHANICAL ENGINEER, 28, desires junior partnership or interest in consulting or contracting firm. Will make investment or consider position on salary. University graduate, 3 years' experience, one year in Europe, in power-generation design and construction, industrial-plant design, investigations. Would consider locating permanently in Europe, particularly Russia. E-162

SUPERINTENDENT or CHIEF ENGINEER, 44, married, technical education. Twenty years' experience as chief engineer in brewery, railroad shops, largest stove foundry in world, and chemical works; manager electric light plant, superintendent foundry and machine shop, superintendent ice-machine factory, chief smoke inspector large city, and mechanical superintendent of hospital. Combustion engineering specialty. Desires position in large industrial plant or other responsible position. Highest references. Present salary $3600. E-163

RESEARCH ENGINEER. Assistant professor of mechanical engineering in leading university, ten years' continuous teaching experience, desires to engage for year in commercial research work, either in commercial laboratory or with power-generating equipment. Experience previous to teaching includes several years' commercial engineering and two years' sales work. Would consider instructional work in another school. E-164

MASTER MECHANIC, 29, M. I. T. graduate, '11. Selling experience. At present employed. Open to any live proposition with chance to progress. E-165

PUBLIC-UTILITY VALUATION ENGINEER, 27, M. I. T. graduate. Desires change from present position to one offering more opportunity for advancement. Three years' extensive experience inventory and appraisal water, gas, electric, traction, and telephone public utilities in East, as mechanical engineer in appraisal department of state public utility commission. Thoroughly familiar with efficient methods of construction and management of above corporation. Special training with unit-cost studies, estimation of annual and accrued depreciation, and overhead charges. Author of technical articles on overhead charges and depreciation. Good draftsman. Capable taking charge field or office valuation department. Unmarried. Salary about $2000. E-166

ASSISTANT TO ENGINEER OR SUPERINTENDENT. Graduate mechanical engineer, 22, shop and estimating experience. Seeks position of some responsibility, with good future. Location preferred, Eastern States. E-167

MECHANICAL ENGINEER, graduating from well-known university in June, desires position with future, preferably in connection with consulting engineer's office. References given. E-168

INDUSTRIAL ENGINEER, technical graduate, 31, desires position as general superintendent or works manager in moderate-size plant with view to making permanent connection. At present employed as industrial engineer by large Eastern manufacturing corporation; work

nearing completion with this concern, after six years' service. Wide experience in purchasing materials, employment of all classes of labor, design and layout of factories, and installation of scientific production methods, standardization, and management in various industrial plants. E-169

FOUNDRY MANAGER or SUPERINTENDENT. Practical foundryman, capable of filling any foundry position. Charge of some of largest foundries in country for past 15 years. Best references as to ability. E-170

PLANT ENGINEER. Graduate mechanical engineer, with good practical experience in design, operation, and maintenance of industrial machinery and power plants. Specialized in combustion of anthracite and bituminous coals and generation of cheap power. Experienced in use of electricity in manufacturing plants. Location New York or vicinity. E-171

MECHANICAL ENGINEER, 15 years' experience in power plant and factory design, 10 years in responsible charge, now completing installation of power plant out of town, wishes to return to New York City. Accustomed to take full charge of design, purchase of apparatus and material, supervise construction, etc. Experience includes factory production and special-tool design. Salary $3000-$4000. E-172

PROFESSOR OF MECHANICAL ENGINEERING desires work during vacation, from June 1 to September 20, teaching or practical work. Has had machine-shop and drafting experience. E-173

MECHANICAL ENGINEER, 30, married, desires position with consulting engineer or as works engineer of medium-sized industral plant. Experience on steam-power plant and industrial-plant design and maintenance. E-174

MANUFACTURER'S REPRESENTATIVE. Graduate engineer maintaining engineering office in Twin Cities desires to represent manufacturer of mechanical line in Northwest. E-175

HIGH-SCHOOL HEAD OF DEPARTMENT. Technical and college graduate. Seven years in present position. Five years' shop experience. Employed at present, but desires to make change at end of semester. E-176

PRODUCTION ENGINEER. Graduate M. E. One year preliminary training with well-known firm of efficiency engineers, backed up by 5 years' practical experience in several industries. Have installed and operated cost systems, and organized and supervised work of planning departments. Competent organizer along modern lines, capable executive, and can handle men and produce results. Employed at present, but desires to form new connections, preferably as assistant to factory manager. E-177

PROFESSOR OF MECHANICAL ENGINEERING, technical graduate, 17 years' experience in teaching, engineering and consulting work. Practical experience in commercial engineering; specialized in steam-power plants. Head of department of mechanical engineering in leading university for number of years, and at present head of departments of mechanical and electrical engineering in university of good standing. Location abroad, China preferred. E-178

SUPERINTENDENT or EQUIPMENT ENGINEER. For past two years with large rifle works, in charge of installing equipment, manufacturing and heat treating. Thorough knowledge of modern methods for producing interchangeable parts. E-179

YOUNG TECHNICAL GRADUATE in mechanical engineering, with two years' general shop practice, wishes to change from present position. E-180

MECHANICAL ENGINEER, 30, university graduate. Five years' experience in factory layout, construction, power-plant design, heating and ventilating. Familiar with modern methods of factory and power-plant operation. Desires position as chief engineer or works engineer with manufacturing plant. Salary $250 per month. E-181

ASSISTANT SUPERINTENDENT, PRODUCTION ENGINEER, MAINTENANCE SUPERINTENDENT, CHIEF TOOL DESIGNER. Twenty years' practical experience in shop and drafting room as machinist, master mechanic, shop foreman, tool designer, chief draftsman. Design and supervision of construction tools, labor-saving devices, routing factory layout, installation and maintenance of equipment. Now employed as chief draftsman in munition plant. Seeks position with future. Location immaterial. E-182

MECHANICAL and ELECTRICAL ENGINEER. Technical graduate, 28. Four years in production and engineering; engines, pumps, compressors, motors, and generators. Three years' municipal work, electrical and gas. E-183

ENGINEER and SUPERINTENDENT. Cornell graduate, with extensive experience in designing, purchasing, constructing and operating power plants, track-work transmission lines, distribution lines, car barns, office buildings, foundries, machine shops, chemical plants, tanneries, cotton mills, gun-cotton and smokeless-powder plants, factories of reinforced concrete, flat-slab or mill construction, also structural-steel docks, piling, sewers, and artesian wells, heating and drying systems. E-184

ASSISTANT TO PURCHASING AGENT. Varied practical and office experience, engineering materials, electrical and mechanical equipment and matters pertaining to construction. E-185

MECHANICAL ENGINEER. Stevens graduate, 26, married. Experience in steel-rolling mill. Desires position as works engineer. At present employed. East preferred. E-186

EXECUTIVE, until recently connected with one of Detroit's largest automobile concerns, desires responsible position. Experienced in modern methods of economical, intensive manufacturing. Competent to organize and handle large bodies of men. Selling experience this country and abroad. Salary $10,000 to $15,000, depending on character of employment offered. E-187

AUTOMATIC MACHINE DESIGNER, experienced in designing special machinery to economize labor and facilitate production. Has inventive faculty. Could reduce cost and increase production of plants manufacturing specialties. Permanent employment not required, but will study problems, make suggestions, and design special machines, tools, and attachments. Available about June 1. E-188

GRADUATE in mechanical engineering, '14, two years' experience in general testing work, with some machine-shop and foundry experience, desires position as testing engineer or assistant to engineer in charge of power plant operation. E-189

GRADUATE M. E., 25, Chinese, one and a half years' experience in shops and office, desires situation with aeroplane company or manufacturing concern with commercial interests in the Far East. E-190

MECHANICAL ENGINEER or ASSISTANT SUPERINTENDENT, technical education, 31, married. Twelve years' experience in manufacturing plants as toolmaker, toolmaker foreman, machine designer, chief draftsman, factory superintendent, and now as mechanical engineer in large rifle factory. Fully conversant with interchangeable manufacture. Salary $2600 per year. E-191

MECHANICAL ENGINEER. Technical graduate, 12 years' practice, desires change. Especially experienced in modern methods of boiler-room operation and maintenance, designer on heavy machinery, designer and engineer of construction on steel-frame buildings, plain and reinforced concrete. Experienced executive. E-192

ASSISTANT SUPERINTENDENT or EXECUTIVE, American, 36, technical education. Twelve years in drafting room, including chief draftsman; six years' shop experience, one as foreman. Practical mechanic, familiar with design of special machinery, tools, jigs, fixtures, etc., for manufacturing duplicate parts on interchangeable system. Salary $2000 per annum. Location preferred, Eastern States. E-193

EXPERIMENTAL or WORKS ENGINEER, RESEARCH ENGINEER, PROFESSOR OF MECHANICAL ENGINEERING. Experienced mechanical and civil engineer, now engaged in munition manufacture, open for engagement. Graduate of leading university, also member S. A. E., experienced in teaching and engineering work of all kinds. Would locate in England or France. E-194

DESIGNING ENGINEER, 30, married. Ten years' English and American experience in commercial trucks, tractors and motor fire apparatus; exceptional experience on front-wheel-drive trucks and interchangeable manufacture. Associate Member M.I.M.E. Minimum salary $2400. E-195

MECHANICAL ENGINEER, ten years' experience in coal and power-plant testing, and design and use of instruments for obtaining highest economy. Desires position with consulting engineer or testing department of large operating company. E-196

FUEL ENGINEER. Graduate M. E., 28. Three and a half years' shop experience. Three years with anthracite and bituminous coal mining companies; mining, preparation, sales, specifications, contracts, laboratory, and power plant testing. Experience with Federal Bureau of Mines and consulting engineers. At present employed. E-197

COLUMBIA GRADUATE, M. E., two years' experience in production and inspection departments, both in shop and in office, would accept position near New York City offering opportunity for advancement. Salary to start $1300. At present employed. E-198

ENGINEERING SURVEY

A Review of Engineering Progress and Attainment in Mechanical Engineering and Related Fields, Including a Digest of Current Technical Periodicals and a Selected List of Engineering Articles

THE scope of the Engineering Survey has now been extended to include a monthly review of progress and attainment in the mechanical engineering and related fields, in accordance with plans developed by the Publication Committee. In this number, issued at the beginning of our participation in the great war, foremost attention is given to the agencies through which engineers are working in coöperation with the Government *to bring the war to a successful issue.* These are mainly comprised by the Naval Consulting Board, the National Research Council, the Advisory Commission of the Council of National Defense, the Federal Shipping Board, and the National Advisory Committee for Aeronautics; together with the various sub-committees and boards organized under the direction of these major bodies. The constitution and objects of these organizations are described, as well as some of their most important accomplishments to date.

The Naval Consulting Board

THE first concerted effort toward coöperation between the Government and civilian engineers in this country was made in 1915 when Secretary Daniels of the United States Navy Department invited eleven engineering and scientific societies to form an advisory board of 23 members, constituting the Naval Consulting Board, headed by Thomas A. Edison. The American Society of Mechanical Engineers was represented on this board by 12 members, two, W. L. R. Emmet and Spencer Miller representing it officially.

The Naval Consulting Board resolved itself into committees, one of which, headed by Howard E. Coffin, Mem.Am.Soc.M.E., was the Committee on Production, Organization, Manufacture and Standardization. This Committee formulated a plan for a census and classification of the manufacturing establishments of the country which was effected through individual and painstaking work by members of the National Societies of Civil, Mining, Mechanical and Electrical Engineers and the American Chemical Society. A director for each State in the Union was appointed by each society, whose immediate work was to obtain an accurate inventory of the facts necessary to be known to the Army and Navy about the capabilities of our Nation to supply munitions in case of war.

This great work was carried through successfully and the returns received from 27,000 of the larger plants showed most impressively the almost unlimited resources which Industrial America is now able to place at the disposal of the Government for the prosecution of the war.

The data collected by the Committee on Industrial Preparedness of the Naval Consulting Board have been turned over to the Council of National Defense, where they are at the disposal of Director Walter S. Gifford, who had charge of the tabulation of the statistics as they were accumulated by the Committee on Industrial Preparedness.

The Naval Consulting Board is now devoting its attention mainly to passing judgment upon inventions submitted to the War and Navy Departments, so that the Nation may not only have the advantage of the work of its inventive citizens, but also will be shielded from having to consider worthless or unpromising inventions. The Secretary of the board is Thomas Robins, 13 Park Row, New York.

National Research Council

THE National Research Council of the National Academy of Sciences was formed at the request of the President of the United States in September 1916, for the promotion and furtherance of scientific research. The conception of the National Research Council is due to Dr. George E. Hale, Director of Mount Wilson Solar Observatory, who has visited Europe in order to obtain information upon the steps that were being taken in England and France in research and in coördinating the activities of scientific men for the purposes of war.

The officers of the Council are: Chairman, George E. Hale; First Vice-Chairman, Charles D. Walcott; Second Vice-Chairman, Gano Dunn, Mem.Am.Soc.M.E.; Secretary, Cary T. Hutchinson, Mem.Am.Soc.M.E., the office of the Secretary being in the Engineering Societies Building, New York. The Chairman, Dr. Hale, was authorized to appoint an executive committee to consist of ten members, in addition to the President of the National Academy of Sciences, Dr. William H. Welch, the Chairman and the two Vice-Chairmen. Dr. Hale appointed the following members: J. J. Carty, Russell H. Chittenden, Edwin G. Conklin, Gano Dunn, Mem.Am.Soc.M.E., Robert A. Millikan, Arthur A. Noyes, Raymond Pearl, M. I. Pupin, S. W. Stratton, Mem.Am.Soc.M.E., and Victor C. Vaughan.

The work of the Council has been carried on by the Executive Committee, which has held twelve meetings, the outcome of which is principally the appointment of a number of committees to report upon and organize research in different branches of science.

Military Committee. First in importance is the Military Committee for governmental research requirements, composed of three representatives of the Army, General Gorgas, General Crozier and General Squier, the heads, respectively, of the Medical, Ordnance, and Signal Corps Departments of the Government; of four representatives of the Navy, Admirals Taylor, Griffin, and Earle, and Dr. Gatewood, the heads, respectively, of the Construction, Engineering, Ordnance, and Medical Departments of the Navy; and of the heads of certain civilian bureaus of the Government. This committee will operate more or less independently.

Census of Research. This committee, acting under Dr. Stratton, is preparing to make a census of all research men and materials in the United States.

Research in Industrial Institutions. This represents an undertaking of great importance, under the direction of Mr. Carty. This committee expects to devise means by which the smaller industries can have the advantage of scientific re-

search through some scheme of coördination and the employment of some existing research means for the purpose of doing the work itself.

Nitrate Supply Committee. This committee is directed by Dr. A. A. Noyes, and it has already done noteworthy work. It has been asked to advise the Government regarding the expenditure of $20,000,000 that Congress has appropriated for the purpose of providing a supply of nitrates; hence its work has an immediate practical bearing.

The personnel of an Engineering Committee is now being completed, as explained in the Society Affairs section of this number in the communication from Mr. Gano Dunn.

The Engineering Foundation, which is administered under the auspices of the United Engineering Society and the national Societies of Civil, Mining, Mechanical and Electrical Engineers has placed its funds at the disposal of the National Research Council for organization and operation expenses.

The National Research Council is maintaining close relations with the Council of National Defense in its work and preparation for the industrial activity which will accompany the prosecution of the war.

Council and Advisory Commission of National Defense

COINCIDENT with the Naval Consulting Board there was in process of formation the Council of National Defense which was organized as a result of the act of Congress of August 29, 1916, "for coördination of industries and resources for the national security and welfare." It was "to consist of the Secretary of War, the Secretary of the Navy, the Secretary of the Interior, the Secretary of Agriculture, the Secretary of Commerce and the Secretary of Labor."

The act further provided for the appointment by the President of the United States of an Advisory Commission of seven members having "special knowledge of some industry, public utility or the development of some natural resources or be otherwise specially qualified.. . . ." Two months later, the Commission was appointed, as follows:

Daniel Willard, President, Baltimore and Ohio Railroad

Howard E. Coffin, Mem.Am.Soc.M.E., Vice-President, Hudson Motor Car Company

Dr. Hollis Godfrey, Mem.Am.Soc.M.E., President of the Drexel Institute

Julius Rosenwald, President, Sears, Roebuck and Company

Samuel Gompers, President, American Federation of Labor

Bernard M. Baruch, Financier

Dr. Franklin H. Martin, Surgeon

The members of the Advisory Commission serve in a consulting capacity without compensation and are in practically constant attendance at Washington.

The organization opens up a new and direct channel of coöperation between business and scientific men and all departments of the Government, and constitutes a rallying point for civic bodies working for the national defense. Among other functions defined by President Wilson are: (1) coördination of all forms of transportation and the development of means of transportation to meet the military, industrial and commercial needs of the case, and (2) the extension of the industrial mobilization work of the Committee on Industrial Preparedness of the Naval Consulting Board.

One of the chief objects of the Council is to inform American manufacturers as to the part they can, and must, play in the national emergency. It has established and maintained through subordinate bodies of specially qualified persons, auxiliary organizations composed of men of the best creative and administrative capacity.

The constitution of the Council and Advisory Commission of National Defense is as follows:

THE COUNCIL

The Secretary of War, Chairman; the Secretaries of the Navy, Interior, Agriculture, Commerce and Labor.

THE ADVISORY COMMISSION

Headquarters, Munsey Building, Washington, D. C.

Daniel Willard, Chairman; and Messrs. Baruch, Coffin, Godfrey, Gompers, Martin, and Rosenwald as enumerated above.

Director of the Council and of the Advisory Commission, Walter S. Gifford.

Secretary of the Council and of the Advisory Commission, Grosvenor B. Clarkson.

Chief Clerk and Disbursing Officer, E. K. Ellsworth.

COMMITTEES

1 Transportation, including railroad and motor transportation, and Communication, Daniel Willard, Chairman.

2 Munitions, Manufacturing, including standardization and industrial relations, Howard E. Coffin, Chairman.

3 Raw Materials, Minerals and Metals, Bernard M. Baruch, Chairman. Sub-Committees: Oil, Wool, Steel, Nickel, Copper, Leather, Rubber, Brass and Aluminum.

4 Labor, including conservation of health and welfare of workers, Samuel Gompers, Chairman.

5 Supplies, Clothing, etc., Julius Rosenwald, Chairman. Sub-Committees: Cotton Goods, Woolen Goods, Shoes and Leather.

6 Science and Research, including engineering and education, Dr. Hollis Godfrey, Mem.Am.Soc.M.E., Chairman; Dr. Henry E. Crampton, Vice-Chairman.

7 Medicine, including general sanitation, Dr. Franklin H. Martin, Chairman.

COMMITTEES OF ADVISORY COMMISSION

The Transportation Committee mentioned above was organized under the direction of Daniel Willard, with the assistance of the American Railway Association which met in conference at Washington and nominated members for the committee. There are four sub-committees working with the Department Commander in each of the four military divisions of the country, to provide for rapid transportation of troops and supplies in times of emergency. Another sub-committee has been formed representing the leading telephone and telegraph companies of the country, headed by Theodore A. Vail. A Motor Transport Committee, headed by Alfred Reeves, General Manager of the National Automobile Chamber of Commerce, has been appointed for the purpose of mobilizing the motor vehicle resources of the country for emergency purposes.

The Munitions Manufacturing Committee, of which Howard E. Coffin, Mem.Am.Soc.M.E., is Chairman, supervises the work of sub-committees on munitions, and all matters pertaining to the selection of manufacturers for the production of munitions, and assists manufacturers in getting out the work properly and without delay. An aircraft board coming under the general direction of this committee is now being formed.

The Raw Materials Committee has been estimating the amount of materials that would be needed to put an assumed force of one million men in the field and the provisions and supplies required for each 90 days of service. Sources of

supply are to be studied and it is expected to be able to determine in advance any deficiencies which may exist in the resources of the country. This committee, at the instance of Mr. Baruch, has secured action whereby copper will be supplied to the Government at 16 2-3 cents per lb. and steel at greatly reduced prices.

Committee on Labor. Mr. Samuel Gompers, as Chairman, is working in coöperation with Mr. Coffin whose committee is charged, among other duties, with the question of industrial relations and proper method for building up an industrial reserve. Whereas a soldier may be made in a few months, it requires a corresponding number of years to make a skilled mechanic. Mr. Coffin has recently remarked that "in modern warfare the blood of the soldier must be mingled with three parts of the sweat of the man in the mills."

Committee on Science and Research, under the direction of Dr. Hollis Godfrey, Mem.Am.Soc.M.E., has been working out a fundamental plan for education in the higher institutions of the country during the period of war which, however, is primarily as a basis for peace. This plan considers, among other matters, the placing of emphasis on such branches of engineering or other subjects as pertain to the efficient production of materials of war, or to efficient work on the part of young graduates entering into Government service. This committee, also, enlists the service of engineers in whatever capacity they may be needed by the Council during the period of the war. Other developments of this committee are now reaching the point of publication and will be referred to from time to time.

SUB-COMMITTEES AND BOARDS

There have also been various sub-committees and boards appointed by the Council and Advisory Commission, of which the following are of the greatest interest to engineers:

Munitions Standards Board, under the general direction of the Munitions and Manufacturing Committee, dealing, in coöperation with the Government, with drawings and specifications, jigs, fixtures, etc.; Frank A. Scott, Mem.Am.Soc.M.E., Vice-President, The Warner and Swasey Company, Cleveland, O., Chairman. The other members are:

William H. Van Dervoort, Mem.Am.Soc.M.E., President, Moline Automobile Company, Moline, Ill.

Edward A. Deeds, Mem.Am.Soc.M.E., President, The Dayton Engineering Laboratory Company, Dayton, O.

Francis C. Pratt, Mem.Am.Soc.M.E., Assistant to President, General Electric Company, Schenectady, N. Y.

Samuel M. Vauclain, Mem.Am.Soc.M.E., Vice-President, The Baldwin Locomotive Works, Philadelphia, Pa.

John E. Otterson, Mem.Am.Soc.M.E., Vice-President, Winchester Repeating Arms Company, New Haven, Conn.

This Board, with other agencies, is bringing to the War and Navy Departments the knowledge acquired by the manufacturers of the country in making munitions for foreign governments, and other expert knowledge regarding the requirements for quantity production which is essential in the preparation of the proper drawings and specifications by the War Department. It is adapting peace-time standards to war-time conditions and endeavoring to avoid the difficulties of production which were encountered at the outset by the Allies. At that time Germany was the only country which had the methods of manufacture carefully worked out in detail. The experience of the belligerent countries in these matters is invaluable.

An important sub-committee of this board relates to small arms and ammunition, of which J. E. Otterson is Chairman. Like the larger committee, this one is endeavoring to coördinate the ideas of manufacturers and of the Government and to standardize materials and design as far as practicable under the existing emergency conditions. Consideration is being given to the use of manufacturing facilities as they now exist, as a result of the orders placed by foreign governments, in order to render the promptest service possible.

It is expected that the Government will accept foreign designs in some instances at least, in order to bring about prompt delivery through the utilization of equipment, jigs, fixtures, etc., that are already in existence and in working order. Where designs can be changed to conform to United States Government standards without causing material delay in delivery, this will probably be done. In the case of rifles, a foreign design has been proposed; but in the case of cartridges, it is likely that the Government will require the United States Government cartridge.

General Munitions Board. Following the appointment of the Munitions Standards Board, there was formed a General Munitions Board headed by Frank A. Scott, Mem.Am.Soc. M.E., and comprising in its membership seven representatives of the Army, eight of the Navy, besides Messrs. Baruch, Coffin, Rosenwald and Martin of the Advisory Commission. The Secretary is Chester C. Bolton. The officers serving on the Board were designated by the chiefs of the several departments and bureaus, under authority of the Secretaries of War and of the Navy.

The purpose of the board is to assume the prompt equipping and arming of whatever forces may be called into the service of the country with the least possible disarrangement of normal industrial conditions. Its immediate efforts will be directed toward coördinating the making of purchases by the Army and Navy, to assist in the acquirement of raw material and manufacturing facilities and to establish the precedence of orders; but it is not intended that the board shall have authority to issue purchase orders or to bind the Government in contracts for purchase.

Commercial Economy Board, of which A. W. Shaw, President of A. W. Shaw Company, is Chairman, and Dr. Hollis Godfrey, Chairman of the Committee on Science and Research, is a member. This board is designed to meet in advance problems of war-time distribution and to bring business men together in a scheme of voluntary coöperation to eliminate waste by adopting commercially efficient methods: In short, to nationalize distribution.

Food Board, the Chairman of which is Herbert C. Hoover, Mining Engineer and head of the American Commission for Relief in Belgium. At the time of his appointment, Mr. Hoover sent from abroad, by Associated Press, a strong statement of the needs and opportunities of such a board. He has instituted an inquiry abroad into the methods used to control prices and for the elimination of speculation. From the fact that America must become the food source for a large part of the world's population, he proposes that the Food Board shall take such guiding action as may be necessary to increase the production of food, to conserve as well as to increase farm labor, to instill a willingness for the elimination of waste, to control the exportation of food and to prevent speculation or undue profits.

SIGNIFICANCE OF THE ADVISORY COMMISSION

The importance of the work which the Advisory Commission is accomplishing in this crisis in the Nation's history is per-

haps not fully realized by the engineering public. Legally, the Advisory Commission has no executive power; in point of fact it has at its command information to supply the Nation with the same service that is rendered to the British nation by the representative business men appointed by Mr. Lloyd-George's cabinet for the war reörganization of the British industries. While Mr. Willard, the Chairman of the Advisory Commission, is not the equivalent of the British Minister of Munitions, the service which he is rendering in the capacity of chairman is entirely comparable to that of the British minister, save the legal authorization to enforce his recommendations. The plan is American in its conception and administration. It is believed that as the duties of the commission are now organized no additional cabinet positions will be required in the conduct of the war, since, by informal extension of the power granted to Mr. Willard and his colleagues, as occasion may demand, the growing activities of the Government will be amply provided for.

National Advisory Committee for Aeronautics

ANOTHER important board is the National Advisory Committee for Aeronautics, organized under Act of Congress of March 3, 1915, from representatives of Government departments and expert engineers and scientists nominated by the President.

The board as at present composed consists of the Secretary of the Smithsonian Institution, Dr. Charles D. Walcott; the Director of the Bureau of Standards, Dr. S. W. Stratton, Mem.Am.Soc.M.E.; the Chief of the Weather Bureau, Prof. Charles F. Marvin; two officers of the Navy, two officers of the Army, and an officer of the Treasury Department. These representatives of Government bureaus are supplemented by four scientists at large, namely, Prof. Michael I. Pupin, of Columbia University; Prof. Joseph S. Ames, of Johns Hopkins University; Prof. John F. Hayford, of Northwestern University, and Prof. William F. Durand, Mem.Am.Soc.M.E., of Leland Stanford Junior University, Chairman.

Shortly after its organization the National Advisory Committee entered into an arrangement with various industrial companies specializing in aeronautical supplies and with several universities to conduct investigations on various matters of importance in the new art. Thus an investigation on pitot tubes was entrusted to the Bureau of Standards, and the Weather Bureau was commissioned to undertake the preparation of a report on the problem of atmospheric conditions in relation to areonautics.

The John A. Roebling Sons Co. undertook an investigation of aviation wires and cables. The Goodyear Tire and Rubber Co. was asked to investigate the relative worth of improved fabrics, and the United States Rubber Co. the allied subject of balloon and aeroplane fabrics.

At Leland Stanford Junior University an aeronautics laboratory was equipped and extended experiments are under way on the performance of different designs of propellers. Finally, Columbia University was given the difficult and important subject of thermodynamic efficiency of present types of internal combustion engines.

The reports of the advisory committee as a whole, and the various organizations entrusted with special investigations, in so far as they have been published, represent contributions to the science of aviation of the greatest value. Thus, Report No. 11, entitled *A Preliminary Study of the State of the Art of Carburetor Design*, prepared by Charles E. Lucke, Mem.Am.Soc.M.E., Professor at Columbia University, is a volume of 552 pages, probably the most complete and exhaustive study of carburetor design and performances available in any language.

Since the formation of the National Advisory Committee it has acted as the central source of information and research, as well as the clearing-house on all work on aviation carried on by the Government. In addition it has done valuable work in bringing together manufacturers of aircraft and accessories and officials of the Government interested in the progress of aviation. These conferences have been of great value in clearing up the ideas of all concerned.

The Advisory Committee has also done yeoman service in developing aviation in connection with the work of the Post Office and Treasury Departments. At present it is actively collaborating with the War and Navy Departments and the Council of National Defense.

Federal Shipping Board

OF the civilian organizations, other than those already mentioned, which are rendering expert service to the Government, the most important and far-reaching in its probable effect on the war is the Federal Shipping Board. This board was organized as a result of the Ship Purchase Bill of August 1916, and the names of its members were sent to the Senate by President Wilson in December 1916. William Denman, Merchants' Exchange Building, San Francisco, is the chairman of the board.

As very fully announced in the daily press, plans are being completed for the construction of wooden cargo vessels on a gigantic scale, to be leased to citizens of the United States for operation in foreign trade.

On April 17 the United States Shipping Board Emergency Fleet Corporation was chartered in the District of Columbia, with a capital stock of $50,000,000, the amount authorized by Congress for the Shipping Board to spend on ships. It is now announced that a bill will be introduced into Congress to increase the capital stock to $225,000,000.

Major General Goethals, at the direction of President Wilson, has agreed to supervise the building of the ships, and in view of the national call upon his services has been released by Governor Edge of New Jersey from his contract to supervise the $15,000,000 expenditure for reconstructing the highways of that State.

The wooden ships are to be of 2000 to 3500 tons displacement and will probably be equipped for oil burning. The ships and engines will be standardized as far as possible, and the boats will carry a crew of about thirty men, will be equipped with wireless, and armed for protection against submarines.

It is expected that the first of the vessels will be ready in about six months. The Shipping Board estimates that 150,000 men will be needed to complete the building program in the time determined on, and upward of 100 private plants will be engaged.

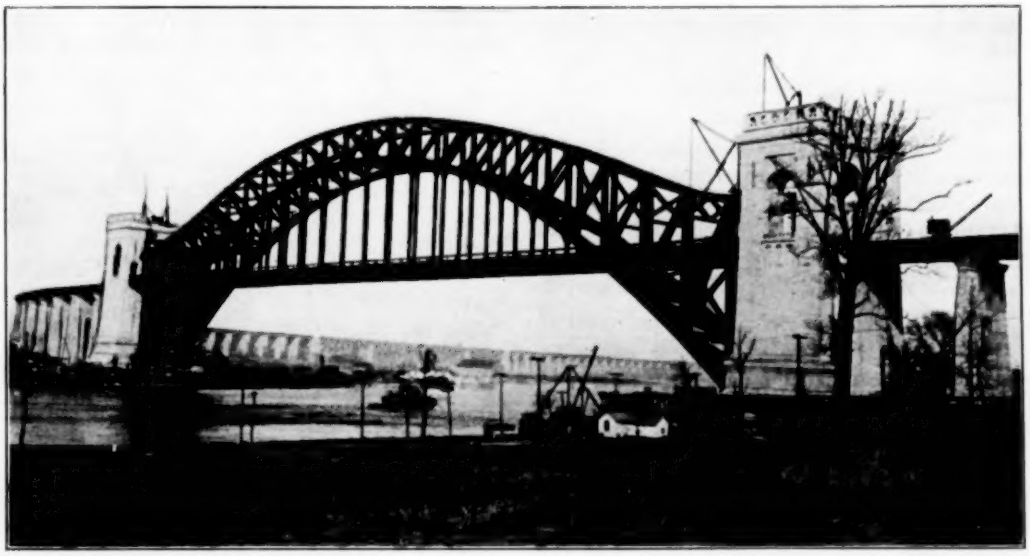
As THE JOURNAL goes to press announcement is made of a newly-created Shipping Committee of the Council of National Defense, with William Denman, chairman of the Shipping Board, at its head. This committee will work in coöperation with the Transportation Committee to facilitate transportation by rail wherever it seems wise to transfer coastwise vessels to trans-Atlantic service.

Opening of Hell Gate Bridge

THE engineering event of the month, from the standpoint of transportation, was the opening to traffic on April 1 of the Hell Gate bridge, the masterpiece of Dr. Gustav Lindenthal, chief engineer, which forms the final link of the the collaboration between its designer and the architect, Henry Hornbostel. The following data are from the *Engineering News*:

Span, 1,016 ft. 10 in. between tower faces; 995 ft. 1⅜ in. between centers of bearings.

Arch, height from center to end hinges to center of top chord,



THE GREAT ARCH OF THE HELL GATE BRIDGE. IN THE BACK GROUND IS SEEN THE LONG APPROACH ON THE NEW YORK SIDE

New York Connecting Railroad between the New York, New Haven and Hartford and the Pennsylvania systems.

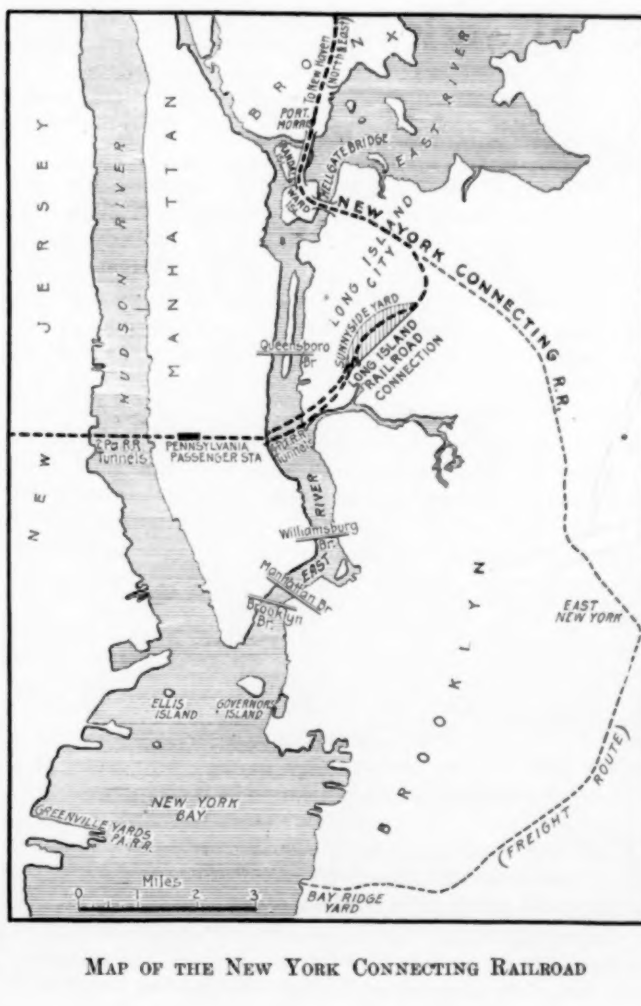
For years New York City may be considered to have been the *dividing point* in the railway lines radiating from it in all directions. Both passengers and merchandise arriving in New York from the South or West had to be transferred in order to go East and North.

The building of the Pennsylvania Station on Manhattan and the construction of the tunnel under the East River to connect with the Long Island Railroad was the first step in the project for through trains and to reduce the ferry distance for the transshipment of freight at New York.

The course of the New York Connecting Railroad is indicated on the map. At 142d Street in the Bronx the line leaves the N. Y., N. H. & H. R. R. tracks, spans one after another the Bronx Kill and Little Hell Gate, and crosses Randall's Island and Ward's Island to the west shore of the East River, after a sweeping curve on the way. From the east shore of the East River the Connecting Railroad continues through Long Island City and then turns to the west, joining the Pennsylvania tracks at the Sunnyside yard. While passenger trains pass through the tunnels and under Manhattan en route to the West or East, freight is to go by belt line around Brooklyn to Bay Ridge on New York Bay, convenient of access by car ferry from the Pennsylvania terminal at Greenville, N. J.

The bridge and viaduct portions of the line from 142d Street in the Bronx to Sunnyside yard on Long Island was a difficult part of the construction. Three miles of it consist of steel spans on concrete piers, with one mile in fill, retained between high concrete walls held together by tie rods.

Apart from its importance as a traffic medium the Hell Gate bridge is also a remarkable engineering construction, if only because it has the longest and heaviest steel arch in the world. It is remarkable also for its beauty of outline, due to



MAP OF THE NEW YORK CONNECTING RAILROAD

140 ft. at ends; 260 ft. at center. Height to center of lower chord, 220 ft. Greatest height above mean high water, 310 ft. Clearance above mean high water, 240 ft.

Towers, height above ground, 240 ft.

Width, 93 ft. between centers of railings; 60 ft. between centers of trusses.

Bottom chord, 6½ ft. wide, 11½ ft. deep at ends, 7½ ft. deep at center; maximum section, 1,384 sq. in.

Heaviest single piece, 185 tons (shipping weight 150 tons).

Load, the arch carries four tracks on ballasted concrete floor; total dead-load, 52,000 lb. per lin. ft. of bridge; assumed live-load, E-60 on each truck.

Of unusual interest to mechanical men are the machine shop problems that were encountered because of the unusual size and weight of the bridge members. All holes and field connections were drilled to match before shipping, an undertaking of extreme nicety. The chord joints are polygonal-faced to secure uniform stress distribution and were planed. This necessitated having the roof of the planer house removable in order to handle the chords, for which latter purpose a 185-ton gantry crane was built.

N.Y. State Barge Canal to be Opened

BY courtesy of Frank M. Williams, State Engineer, State of New York, the following data are published on the New York State Barge Canal, which will be opened on May 15 for through navigation between tidewater at Troy to Whitehall on Lake Champlain. The entire canal will be opened in May 1918, at which time through navigation will be available on the new channel between Troy and Tonawanda, where the Niagara River is entered and followed to Buffalo on Lake Erie. This summer, however, boats using the Erie will follow the new channel to a point north of Syracuse where the Oswego branch is encountered, and from there on to a point west of Rochester will have to use the old canal at places owing to the incompleted condition of the new channel. From Rochester on to Tonawanda the canal is completed.

Regardless of this feature, however, one boat line has awarded contracts calling for the construction of eight self-propelled barges each 150 ft. long and 22 ft. wide with a draft of 6½ ft. and a capacity of upwards of 600 tons. These barges are to be completed in 1918 and will be of steel construction with a wood lining which is calculated to protect the cargoes from heat. They will be driven by semi-Diesel fuel-oil engines.

Foremost among the various structures on the canal are the locks. These are all constructed of concrete and are operated by electricity which is generated at hydroelectric stations or gasoline-electric plants which are located on the various locks. A notable lock is that located at Oswego. This has a lift of 25 ft. and utilizes the siphon principle. It is the largest lock of this type in the world and the first to be constructed in this country. Four other locks of considerable note are those located at Lockport and Seneca Falls, there being a flight of two at each place, with a combined lift of each flight of 48 ft. The New York State Barge Canal has cost the State $150,000,000.00 to construct.

Curtis Bay Coal Pier at Baltimore

THE new export coal pier of the Baltimore and Ohio Railroad at Curtis Bay, Baltimore Harbor, said to be the largest in the world, has a handling capacity of 12,000,000 tons a year, or a maximum of 7000 tons an hour, and is the first of its type. At the land end are two car dumpers, and on a concrete deck 8 ft. above mean tide are four loading towers and two trimming towers, to which coal is delivered by belt conveyors from receiving hoppers at the car dumpers or from the balancing bin interposed between the dumpers and the piers.

The tracks leading to the dumpers are on a descending grade, the cars running to the barney pit by gravity. The barney pushes the cars up the 10 per cent grade to the cradle of the car dumpers, where each, after being clamped, is turned upside down, delivering its contents to a counterweighted apron, which is raised when a car is being dumped, in order to minimize breakage. Each car dumper has three 60-in. belts with a capacity of 2000 tons an hour when traveling 500 ft. per min.

Each loading tower is equipped with a cage supporting a shuttle ram, and this cage may be raised or lowered to suit the height of the vessel being loaded, thus providing a further precaution against the breaking of the coal. The apparatus will load a hatch uniformly and reduce trimming to a minimum.

The two trimming towers, located on either side of the pier, have belts 48 in. wide with a capacity of 1500 tons an hour when the speed is 500 ft. per min. Coal for these belts is taken from the balancing bin. The trimming towers have 48-ft. swinging booms and are used for loading the bunker coal and also for finishing the slow work on a vessel, thereby releasing the loading towers for work on another vessel.

The functions of the tower are interlocked and controlled electrically, with push buttons located every 20 ft. on each belt-conveyor runway, and by pushing a button all movable parts of the belt, tower, and feeding are stopped. The operators are located in houses on the shuttles. The master control of the pier is located in the superintendent's office, enabling him to establish the maximum speed at which the belts are run.

The installation described here is interesting not only because of its large capacity and low drop, but also because it is the first attempt on such a large scale in this country at coal loading by mechanical means rather than gravity. (*Railway Review*, March 24, 1917.)

Huge Canadian Air Camp

BEFORE summer, Canada will have a $5,000,000 aviation camp located at Camp Borden, north of Toronto, as reported by *Flying*, April, 1917. It will be the largest permanent establishment of its kind on this continent. Fifteen concrete sheds 120 by 66 ft., lighted and heated by electricity, are now being finished, and when the barracks are done, the camp will accommodate about 2000 men. This camp represents the first step taken by the Canadian Government in establishing its permanent air defenses, for which $80,000,000 are to be spent. Hitherto the greater number of aviators have been trained at Valcartier, but this camp will soon be given up for this kind of work, on account of the short season there, with its great amount of snow.

There will be 160 experienced military aviators constantly on duty at Camp Borden, either trained by the experts of the Curtiss Company, or selected from the 600 Canadian airmen now in service on the battle fronts of Europe. These 600 men form an available reserve of pilots, who have heard the shrapnel swish by them in actual battle, and know every detail of organization, as well as the work to be done in the air. Plans include training 5000 aviators, but it is not expected that the training of more than 2000 will be finished this year. As soon as pilots are graduated from the school they will be assigned to permanent camps, which will be scattered all over Canada. The localities of these camps, except Camp Borden, have not been announced.

Electric Propulsion on Battleships

THE recent decision to build battleships of the largest size with electric drive lends interest to the battleship *California,* of this general type, under construction at the New York Navy Yard. Her displacement is 32,000 tons and her maximum speed is to be about 22 knots, requiring about 37,000 shaft hp.

The equipment will consist of two turbine-driven generating units, four propelling motors, one for each shaft, two turbine-driven exciting units, and a complete equipment of condensing auxiliaries and ventilating blowers, all driven by motors from the exciting units.

The generators for the *California* are bipolar alternators, and the motors are arranged to be connected either for 24 poles or 36 poles. For economic cruising only one generator will be used, with motors on 36-pole connection. For higher speeds the 24-pole connection will be used.

Speed variation with either motor connection will be effected by change of turbine speeds through variable speed governors. This arrangement has been used in the *Jupiter* and entirely prevents racing.

Each of the auxiliary units is of 300 kw. capacity and a 240-volt direct-current generator geared to a high-speed non-condensing turbine. These turbines exhaust into the heaters, or main turbines, or both.

The steam consumption guaranteed on the *California* covers the total steam required for the main turbines and engine-room auxiliaries, at 250 lb. gage pressure, dry steam. The guaranteed water rates per hp. delivered to the propeller shaft vary from 14.6 lb. at 10 knots to 11.1 lb. at 19 knots.

W. L. R. Emmet, Mem.Am.Soc.M.E., in a paper read before the Society of Naval Architects and Marine Engineers in November 1915, gave the following comparison of steam consumption per effective hp. between the *California* as guaranteed, the *Florida* and *Utah,* which are driven by Parsons turbines, and the *Delaware,* which is driven by reciprocating engines.

POUNDS OF STEAM TO MAIN ENGINES PER HOUR PER E. HP.

	12 knots	15 knots	19 knots	21 knots	Prop. speed 21 knots
Florida	31.8	——	24.0	23.0	328
Utah	28.7	——	20.3	21.0	323
Delaware	22.0	——	18.7	21.0	122

Standardization of Army Trucks

THE Society of Automotive Engineers points out the vital importance of military motor transportation of troops and supplies. Tens of thousands of trucks will be needed for the armies now being organized in this country, and specifications covering important features of design and construction have been issued by the War Department and are appended to this note.

The standard truck is one of great capabilities, having a very low gear reduction and a large engine. Particular stress is laid on the inclusion of a four-speed transmission and on provision for adequate ground clearance, making possible negotiation of the roughest ground on which the trucks will travel. Demountable tires are considered essential owing to operations at points far distant from supply depots. Large gasoline tanks will be installed. Other items of interest are electric lighting, three-point engine suspension, locking differential, and large power-plant cooling capacity. Particular attention has been given to the spring suspension and the details of body construction. The gage of the wheels will be uniform. There is no doubt that trucks of different capacities excellently suited to the purpose of the Government have been specified. The Quartermaster and other corps of the War Department deserve great credit for this result.

The following are the principal features of the new truck:

Four-cylinder engine, 312 cu. in. piston displacement.
Poppet valves only.
Pressure lubrication.
Disk clutch.
Four speed transmission with low gear ratio of at least 40 to 1.
Preferably worm final drive.
Highest possible clearance, minimum at center about 14 in.
Some form of locking differential acting automatically to prevent wheel spinning.
Electric lighting equipment.
Radiator about twice the size normally used.
36 by 4-in. tires, must be demountable.

Interchangeability of radiators, gasoline tanks, and body-attaching devices are points, and the qualities of materials that must be used are specified, most strongly for such vital parts as the springs.

Submarine Chasers

INFORMATION has been variously published regarding the awarding of contracts by the Government for 110-ft. submarine chasers. The following specifications are condensed from an article to appear in *The Rudder* for May:

Contracts for the building of 345 of the 110-ft. submarine chasers have been awarded by the Navy Department. Of these 210 are to be built in private yards and the remainder in the Navy Yards. The Navy Yard in Brooklyn has started work and will have the first of this fleet ready by June 1. Nine more are to be completed by July 1, and after that ten are to be finished each month until the sixty are finished by December. The New Orleans Navy Yard is to build six, one a month after July 1; the Charleston Navy Yard, eight; the Norfolk Navy Yard, twenty-one; the Mare Island Navy Yard in California, fifteen, and the Puget Sound Navy Yard, twenty-five. These boats are to be built of wood, of 15-ft. beam and 4 ft. 6 in. draft.

The total cost of the 210 boats to be built outside the Government yards will be $10,741,063 and the average price of each boat so built is $51,100. The cost of engines, wireless, guns, fittings, etc., will be extra.

It was first planned to have the boats fitted with two slow-turning gasoline engines of 300 hp. each, giving a speed of 18 knots, but no engines of this type were available and it was decided to use three Standard Motor Construction Company's engines of 200 hp. each, and an 8-hp. engine for auxiliaries.

It is anticipated by builders that contracts may later be placed for boats of 80-ft. length, similar to those built in this country by the Elco Company, which recently completed an order for 550 for the British Government in the record time of 550 days. While boats of this length are undoubtedly less seaworthy than larger boats, reports of officers who have had charge of them in actual service praise highly their sea-going qualities. A marked advantage of the smaller size is the possibility of rapid production. In a boat up to 80 ft. in length, the great majority of parts can be handled by manual labor without the aid of cranes. In the construction of boats of larger size, a considerably larger number of elements must be handled by cranes, which materially retards production.

Inasmuch as the nominal output in this country of large marine gasoline or oil engines probably does not exceed 250 a year, the question has been raised as to whether manufacturers of engines can keep pace with the construction of hulls for the submarine chasers, if put out in large numbers. The Journal has made inquiry regarding this among builders of such engines, who maintain that they will be able to meet probable demands. Estimates are more or less futile, because it cannot be predicted what will be the labor conditions or the possibility of procuring machine tools. The Elco Company had 1100 engines constructed for it in less than two years time.

The Engineering News Record

The consolidation of the *Engineering News* and the *Engineering Record* as a result of the merging of the Hill Publishing Company and the McGraw Publishing Company, brings together into one influential publication, two of the oldest technical periodicals. The combined "Engineering News-Record" appeared on the 5th of April.

The Engineering News was founded in 1874 when George H. Frost published the first copy of the Engineer and Surveyor. The next year the name was changed to the Engineering News. Prominent names successively associated with the journal are D. McN. Stauffer, Arthur Mellen Wellington, and in 1895 Charles Whiting Baker, who has since been its editor and is now the editor-in-chief of the *Engineering News-Record.* In later years, Mr. Frost repurchased a two-thirds' interest in the paper and in 1911 sold the journal to the Hill Publishing Company.

While the Engineering News has always been a paper devoted to civil engineering, the Record until recent years has been more in the field of heating, ventilation and sanitary engineering. It was founded in 1877 by Henry C. Meyer as the Plumber and Sanitary Engineer. It later became known successively as the Sanitary Engineer, the Engineering and Building Record and the Engineering Record.

After conducting the paper for 25 years, Major Meyer sold it to James H. McGraw. In 1902 John M. Goodell became the editor and in 1912 E. H. Mehren, who is now the general manager of the combined McGraw-Hill Publishing Company, was appointed in his place.

The *Iron Trade Review* calls attention to a rather perplexing situation which exists at present in the steel market. Inspection of the quotations reveals the surprising fact that some finished products apparently sell for less than the cost of the raw material from which they are made, and that this selling price seemingly bears but little relation to the cost of manufacture. Thus wire rods are quoted at $75.00 to $85.00 per ton, Pittsburgh. Plain wire made through many processes from the wire rod is quoted at $63.00 per ton, while nails made from this wire are quoted at $64.00 per ton. Plates are selling at $95.00 per ton and sheet bars, which in effect are narrow thick plates, are quoted at $65.00 per ton. Steel bars are $67.00 per ton, while angle bars, which are only bars with holes punched in them, sell at $55.00 per ton. This apparent inconsistency is in part explained by the fact that bars, sheet bars, and other partly finished steel are being bought for delivery in months hence at the quotations named. Wire and nails and sheets now being sold will be made from material bought a month ago at less than present prices.

News of Other Societies

Committee on Engineering Cooperation

Third Conference

The third annual conference of the Committee on Engineering Coöperation was held in the rooms of the Western Society of Engineers, in Chicago, on March 28 and 29. More than forty delegates, representing societies with a membership aggregating 50,000, were in attendance, and at the banquet, which was held on the evening of the second day, nearly 300 were in attendance, representing the members of the engineering societies in Chicago and vicinity.

On the first day, as each society was called, the delegate made an individual response. This was followed by specific papers, one by Mr. W. L. Saunders, Mem.Am.Soc.M.E., on the proposed Civic Scientific Alliance, and the Functions of Engineers' Clubs as illustrated by the Engineers' Club of St. Louis, by past-president F. G. Jonah.

On Thursday afternoon, Dean Potter, of the Kansas State Agricultural College, gave a report on the Land-Grant Colleges. There was also a remarkable address by President J. F. Dennis of the Canadian Society of Civil Engineers, and vice-president of the Canadian Pacific Railway, on the relation of the engineering societies to the war. The resolution, which was adopted with respect to coöperation, is as follows:

RESOLVED, That this conference requests and urges the national engineering societies in designing the engineering council to give consideration to, and create as soon as proper deliberation may permit, the machinery necessary to provide for a general permanent body of representatives of the various national, state and local organizations of the country in the interest of the common welfare and advancement of the profession as a whole.

This refers to the report of a sub-committee on the activities which the engineering societies are urged to undertake, as is shown in the following:

1. National Societies. As a preliminary to all efforts toward coöperation among existing engineering organizations there should be the expressed intent to assist in strengthening and unifying the work of the national engineering societies in the advancement of engineering knowledge and practice and the maintenance of high professional standards.

2. Local Organizations. The invigorating of local societies is fundamental because of the fact that while the great national societies are important in setting standards and in considering broad problems, yet local affairs make up at least nine-tenths of the vital problems of the engineer's life. In each locality where there may be a dozen or more engineers so situated as to be able to meet occasionally, there should be formed, if not already existing, an engineering association embracing all professional engineers and others interested in engineering to discuss and act upon these vital problems.

3. Home Rule. Each local engineering society should be autonomous or self-governed, wholly free in its activities from any dictation or control by other association or connections, fully adapted to local needs and conditions, and exemplifying in its activities the principle of complete home rule.

4. Welfare of Members. Each such local or self-governing unit in its organizations and activities should give full recognition to the fact that the majority of the membership necessarily consists of men not yet enjoying complete or independent professional status, but who in large part have had a college or technical training, and who in time may become professional engineers in the full sense of the word. Because of this diverse character of members, the activities of the local society, while maintaining high professional standards, should be so planned as to meet the needs of the young men as well as the older and be directed toward the welfare of all classes of its members and through them of the public.

5. Ethics. Each local engineering society should adopt and frequently make application of a code of ethics prepared in accord with the standards established by the national organizations or approved by other professional bodies. It is recognized that while it is impossible to prevent all violation of such a code, yet eternal vigilance is the price of maintenance of high standards. The enforcement of such a code is essential to the well being of the community at large as well as for the protection of professional men from the improper competition of unskilled or unscrupulous men tending to reduce the opportunity for effective service to individuals and to the public.

6. Civic Affairs. Each engineering society should devote time and thought to local civic, state and national affairs which influence engineering progress.

7. The Public Engineer. Each local society should give especial attention to the needs of those members who are in public employment, and should recognize the high ideals and performance of the public engineer, seeing to it that he is furnished sympathetic support in his efforts in the public service.

8. Publicity. Each independent association should maintain a local system of diffusing information on engineering subjects such as may be embraced in the term publicity or of proper advertising of the profession as a whole.

9. Employment. For the benefit of the great body of engineers there is needed the development of a scientifically planned and well conducted system of employment to be operated in coöperation by all engineering associations.

10. Conferences. A conference of representatives from each engineering organization should be held at least annually, at which all matters such as those above noted and those of general interest should be discussed.

The impression which I received was that a most earnest and sincere desire exists in those responsible for these conferences, and in the men who attend as representatives of the various local and national engineering societies, to secure, *first*, greater participation of the engineering societies in public affairs as an obligation to society; *second*, a proper ambition to secure recognition for the work of the profession by the public in general, and *third*, as a means to this end, there should be a definite effort to so inform the public about engineering works that the average layman will not only understand, but be actually interested in the manner that he would read other items of news. The conference was naturally gratified to learn the movement was spreading to effect coöperation among the national societies, which was very near completion in what is known as the Engineering Council.

C. W. R.

Engineering Society Organized in Southwest

At a convention held in El Paso, Texas, on March 8, 9 and 10, the Southwestern Society of Engineers was organized with more than one hundred charter members. Membership is open to civil, mechanical, mining, electrical or chemical engineers, or architects or other persons belonging to a technical profession, who are not less than 27 years of age, and who have been in active practice in their profession for at least six years. Provision is also made for associated, honorary and affiliated members.

In sending information about this meeting. Prof. A. F. Barnes, Dean of Engineering of the New Mexico College of Agriculture and Mechanical Arts, State College, New Mexico, states that the idea of the new society occurred to several members of the faculty of the Engineering School, and that its field is to include West Texas, New Mexico and Arizona, where there is little opportunity for the engineers who are widely scattered to get acquainted. Engineers residing in the Southwest are usually unable to attend the national society's meetings, and it was thought that it would be beneficial to all if an organization were perfected by which they could come together and exchange views on subjects of common interest. It is estimated that there are about from 800 to 1000 engineers available for membership.

National Employment Managers' Association

A conference of the National Employment Managers' Association was held at the University of Pennsylvania on April 2 and 3, under the auspices of Employment Managers' Associations of various cities, and several other organizations, local and national. The first day was devoted to a discussion of The Labor Turnover in Industry, with a banquet in the evening, at which there were miscellaneous addresses. On the second day, the subjects were the Selection of Employees and Termination of Employment; and Following Up After Hiring, the latter including a discussion of service work, mutual aid associations, etc. A National Employment Managers' Committee was formed to act as a clearing house among the local associations and to attend to such national affairs of the Society as may come up. There were approximately five hundred in attendance, from sections as far away as California, Georgia and Ontario, Canada. About fifty came from New England and fifteen from Chicago. The proceedings of the conference will be published. The Secretary is Prof. Joseph H. Willits, Wharton School, University of Pennsylvania.

Technical Textile Conference

The second Annual Conference of those interested in the consideration of problems relating to the testing and general technology of textiles and the closely allied materials, cordage, thread, and felt, is to be held at the Bureau of Standards, Washington, D. C., on May 21, and to continue for one to three days as required. Attendance is free to all persons interested. The meeting may consider the advisability of forming a permanent society for the promotion of research. A long list of topics for discussion is appended to the announcement of the conference. One of the subjects mentioned, namely, the determination of the effectiveness of textiles in resisting heat transmission, is of particularly timely interest. The value of an army blanket lies in keeping the soldier under it warm; that is, in the effectiveness of the blanket as a heat insulator. The development of a proper method for determining this quality in textiles would give the War Department a really scientific and reliable method for drawing up specifications for army blankets.

Medals for Safety Museum

The American Museum of Safety announces the following awards of the medals of the Museum for 1917:

The E. H. Harriman Memorial Medals, awarded annually to the American steam railroad most successful during the preceding year in protecting the lives and health of its employes and the public: The gold medal to the Alabama Great Southern Railway, Cincinnati, O., whose report for 1916 shows a remarkable record. Not a passenger was killed; no employes were killed in train accidents; and with more than 2000 industrial workers, none was killed and only two were injured. From minutes of meetings of employes submitted as part of the record, a wholesome stimulation of interest was evident in the direction of accident prevention and the promotion of good health. A silver replica was given to the Illinois Division of the Illinois Central Railway; and a bronze replica

to Mr. James A. McCrea, general manager of the Long Island Railroad Company, for his safety publicity campaign familiar alike to those who motor on Long Island and those who use the trains.

The Anthony N. Brady Memorial Medals, awarded for safety and health to American electric railways: The gold medal and replicas were all awarded to the Connecticut Company or its officers, New Haven, Conn.

The Scientific American Gold Medal, awarded for the most efficient safety device invented within a certain number of years and exhibited in the Museum: To the Pullman Company, Chicago, Ill.

The Travelers Insurance Gold Medal, awarded to the American employer who has achieved greatly in protecting the lives and limbs of workmen: To the Commonwealth Steel Company, St. Louis, Mo.

The Louis Livingston Seaman Gold Medal, awarded for progress and achievement in the promotion of hygiene and mitigation of occupational diseases: To the Julius King Optical Company, New York.

Talk on Aeronautics at Buffalo

Charles H. Manly, consulting engineer of the Curtiss Aeroplane Company, addressed the Engineering Society of Buffalo on April 19 on aeroplanes for the destruction of submarines. He said that in the immediate future there will be very important developments in flying boats. The answer to the submarine will be the flying boat large enough to carry a gun of sufficient caliber to sink a submarine when the latter is submerged or when nothing but its periscope is showing. Such a flying boat might also readily be equipped with torpedoes and tubes for launching them so that it could fight the submarine with its weapons, or it could be used against commerce raiders.

The largest flying machines will be of the marine type, and machines several times the size of any so far made will be seen eventually. The Curtiss flying whale now being tested by the United States Navy in Florida, has an upper wing spread of more than 90 ft.; is driven by two 200-hp. motors and has a boat 46 ft. long, weighing with fuel and pilot more than 5,500 pounds.

Several manufacturers of gears met at Lakewood, N. J., early in April and formed the American Gear Manufacturers' Association, the objects of which are stated to be to promote the interests of the gear industry by the standardization of gear designs, manufacture and application. The president is F. W. Sinram, Van Dorn & Dutton Co., Cleveland, O..

The Society of Terminal Engineers has been recently incorporated under the laws of the State of New York with headquarters in New York City, to promote the study of terminal engineering and mechanical freight handling as a specialty. A partial organization so far effected has H. McL. Harding for president, and J. Leonard as secretary. The office of the secretary is at 133 Broadway, New York City.

With its April issue, *International Marine Engineering* completed its second decade of usefulness as a technical journal of high character devoted to the interests of the shipbuilding industry. The double number marking the anniversary contained special articles dealing with recent progress and developments in the field of marine engineering.

This Month's Abstracts

One of the most significant features of modern engineering is the use of new materials of construction. The nineteenth century will always be known as the one in which was introduced commercially the greatest material of construction which most profoundly affected the life of mankind—that is, steel.

To the present century, however, belongs the honor of the consummation of the art of production of composite alloys, both ferrous and non-ferrous, with definite and often strikingly new properties, and the art of modifying the properties of carbon steel by heat treatment. Among the abstracts in this issue will be found data on developments in both of these latter directions.

H. W. Gillette and E. L. Mack, in a paper to be read at the Kansas City meeting of the American Chemical Society, discuss the so-called ferro-uranium, of interest because of great claims made for uranium steel as a tool steel. The data collected by the authors do not appear to support these claims.

Another article, by James Scott, Mem.Am.Soc.M.E., discusses the use of boron as a purifying and deoxidizing constituent of copper, aluminum, and copper-nickel alloys. This is of interest because, as appears from the work of the present writer, and especially the papers read before the various societies by Dr. Weintraub of the General Electric Company, boron imparts very remarkable physical and electrical properties to copper (compare paper read by Dr. Weintraub before the International Engineering Congress, 1915, vol. 9).

In the field of heat treatment of steel an interesting tendency is disclosed in the article by W. H. Phillips discussing the application of methods of heat treatment as perfected for automobile gears to the case of gear trains in rolling mills. This article suggests a promising subject for laboratory research, namely, the effect of dynamic blows on spur gearing when running at high speed and transmitting heavy loads.

The attention of those interested in locomotive design is called to the important tests of Atlantic type locomotives recently carried out at the testing plant at Altoona of the Pennsylvania Railroad Company.

Gardner T. Voorhees, Mem.Am.Soc.M.E., in *Ice and Refrigeration,* presents the results of a highly interesting investigation into the still somewhat unexplored region of the latent heat of ammonia. Substantially the work is based on experimental data previously published by Prof. J. E. Denton in the *Trans.Am.Soc.M.E.,* but the writer develops a new method for determining the value of the latent heat of ammonia and presents a series of interesting considerations on this subject. The matter of heat losses in the expansion valve is treated in this article with great thoroughness.

How much may be gained by a closer insight into comparatively simple phenomena is well illustrated by F. R. Low, Mem.Am.Soc.M.E., on Energy Stored in a Boiler Under Pressure, in *Power.* The writer discusses essentially the question whether the work done in forcing back the environment when water changes to steam should be included in calculating the energy released by a pound of water under certain assumed conditions. The interest of the article lies, however, in the fact that it brings out with great clearness the proper way of treating the various constituents forming the total energy released when a boiler under pressure explodes.

Attention is called to the advance notices of technologic papers on Glasses for Protection of the Eyes from Injurious Radiations in the Section *Safety Engineering,* and on Temperature Measurements in Bessemer and Open-Hearth Practice in the Section *Measurements,* published by courtesy of the U. S. Bureau of Standards.

REVIEW OF ENGINEERING PERIODICALS

SUBJECTS OF THIS MONTH'S ABSTRACTS

Air Machinery

Blast-Furnace and Steel-Mill Power Plants, Richard H Rice and Sanford A. Moss

Discussion of the most economical type of plant when all costs are included. A comparison of turbo-blowers for blowing and turbo-generators for generating electric power for steel mills from surplus gas on one side, with a plant using gas directly in gas-engine-driven blowers and generators on the other hand. Complete tabulations of the cost of operation of each plant for four blast furnaces are given; compare Table 1.

The writer discusses the centrifugal-compressor blast not only from the point of view of cost, but also from that of effect on the furnace, and calls particular attention to its steadiness and easy controllability.

As regards the value of accurate control of the rate of air flow in the case of a blast-furnace compressor, the writer quotes the following experience. The measuring device which was relied upon to determine the rate at which the blast was being blown was so located that the indications were inaccurate. This resulted in an inaccurate adjustment of the machine. After a considerable period of operation under these conditions the measuring device was so relocated as to make it more accurate. As a result the quantity of dust is said to have decreased to normal, and the output of the furnace increased.

The writer describes in this connection the governor used on blast-furnaces blowers built by the General Electric Company. A recent improvement of this governor consists of a means of adjusting the index on the sliding weight to compensate so that the weight can readily be set to take account of the variations in atmospheric conditions. This device is called a volume director.

In the early days of our experience with centrifugal compressors on blast furnaces there used to occur the so-called "surging," which appeared when the machines were operated at considerably less rates of blowing than those for which they were designed, or when excessive pressures were met with as in case of tightening up of the furnace. This "surging" consists of an alternate forward and backward flow of air with the compressor, and is the result of improper functioning of the discharge vanes owing to the variation of blowing conditions from those for which the vanes were designed. The steps which have been taken to eliminate this "surging" are reasonable proportioning of the machine to the requirements of the furnace, and provision of a by-pass with an automatic valve which in conditions which would ordinarily permit "surging" leads back into the inlet a small quantity of air.

The major part of the paper is devoted to a discussion of comparative costs of the two types of plant, turbine- and gas-engine-driven. (*Proceedings of the Engineers' Society of Western Pennsylvania*, vol. 33, no. 2, March 1917, pp. 81-130, 6 figs. *c*)

TABLE 1 COMPARATIVE COSTS FOR TYPICAL FOUR-FURNACE PLANTS

First Costs	Gas Engine.	Steam Turbine.
Primary Washers	$131,250	$131,250
Secondary Washing Station	300,000	......
Gas Pipe from Boiler House	212,500	......
Boiler and Piping	167,500	609,200
Boiler House	41,250	123,750
Electric Station Apparatus	3,250,000	745,600
Electric Station House	250,000	69,200
Blowers, etc.	1,812,500	726,416
Blowing Station House	237,500	69,200
Pumping Station, Standpipe, Conduits	787,500	293,484
	$7,190,000	$2,768,100
Charges, Dollars per Year		
Primary Gas Washers	$2,100	$2,100
Secondary Gas Washers	42,000	......
Boilers	12,000	52,750
Electric Station	90,000	68,250
Blowing Station	49,500	42,000
Pumping Station	6,000	4,000
Running Charges, Total	$201,600	$169,100
Fixed Charges at 13 per cent	934,500	359,800
Coal	21,652	78,352
Total Charges	$1,157,752	$607,252

Chisels

Chipping Defects from Steel Billets

Chipping is a costly practice, and unless properly handled may become excessively so.

Unskilled labor of the cheapest type obtainable proves to be the best suited for this work; in fact, no other can be had, as the job of chipping is extremely unpleasant, because of the constant jar of the hammer and the stooped-over position necessitated by the work. Under present conditions 25 cents or more per hour is an average price paid to chippers working ten hours per day, and unless the chippers are kept working as constantly as possible, the costs mount up incredibly.

The job is a hard one and chippers will avail themselves of the slightest excuse to stop work. An investigation recently carried out in a large steel plant in the Central West showed that most of the time lost arises from chisel breakage, or, in general, defective chisels.

This investigation is altered in the development of certain methods which are said to have reduced the cost of the operation. Where billets require chipping a thorough inspection must cull out the defective ones.

As regards the chipping hammers, Fig. 1 shows an improved type of two-piece nozzle used for holding the conical-shank chisels found more satisfactory than the type formerly used. The air consumption per hammer is 19 cu. ft. per min.

In order to keep air hammers in good working condition they must be properly cleaned and oiled at frequent intervals. For lubrication a small amount of clean light machine oil should be poured into the inlet of the handle, and when the tool is being constantly used, this should be done every two or three hours.

The matter of chisels is of very great importance. A typical steel for chipping chisels at one plant analyzed as follows: carbon 0.70 to 0.90 per cent, sulphur 0.035 per cent, phosphorus 0.015 per cent, and manganese 0.20 per cent.

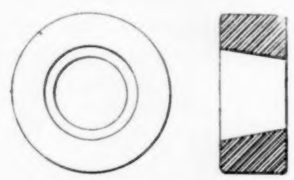


Fig. 1 New 2-Piece Nozzle For Air Hammer

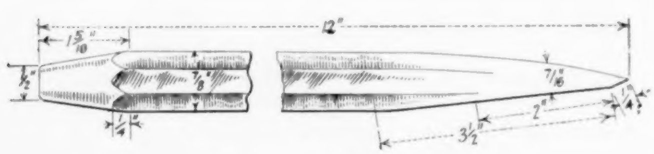


Fig. 2 Standard Half-Round Chisel

Each chipper needs from six to twelve chisels on hand at all times. Where chisels are used in large quantities it is found economical to have shanks machined outside at contract prices. Forging, shaping, and heat treatment are best performed in the plant, because of the necessity for having a repair man on chisels most of the time. Chipping chisels are subject to severe service requirements and rough treatment. Hence the steel should be put in the best possible condition. No rule-of-thumb heat treatment is effective, and the results of the tests conducted demonstrate the superiority of chisels treated under pyrometric control.

Experience has shown that straight 0.70 to 0.90 per cent carbon steel is well adapted for chipping chisels. A number of experiments were carried out at the plant referred to in this article for the purpose of standardizing the heat treatment of chisels. The following treatment was finally devised: Chisels of 0.80 per cent carbon steel were heated to 735 deg. cent., or just through the critical range, in a gas-fired muffle furnace having uniform temperature. Fifty chisels were charged at once and allowed to soak until a pyrometer rod in the middle of the pile showed 735 deg. cent. The assumption was that the entire pile of chisels had attained at least that temperature. Readings with the pyrometer at different places in the pile showed this assumption to be sufficiently accurate for practical purposes. When up to heat, the chisels were quenched by immersing the point about 1.5 in. in water. The strains induced by this drastic quenching were relieved and the resultant hardness mitigated somewhat by drawing the chisels at 250 deg. cent. in a bath of high-flash quenching oil. The drawing temperature was discovered by trial of the chisels. Lead baths for heating the chisels prior to quenching are preferable.

A great deal of trouble with chisels is due to improper grinding methods. The steel is injured by "drawing the temper," which really means that sorbite and pearlite are formed as the critical range is approached, as well as by checking and service cracks. For hard carbon chisels grinding wheels of fine grain are recommended, and the pressure during grinding should be light.

As regards the shape of the chisels, a half-round chisel proved to be the most suitable for the purpose. The one shown in Fig. 2 was adopted as standard. (*The Iron Trade Review*, vol. 60, no. 12, March 22, 1917, pp. 682-684, 4 figs., p)

Engineering Materials

Ferro-Uranium, H. W. Gillet and E. L. Mack

General discussion of uranium-iron alloys, their production and properties.

According to the information collected by the author the use of uranium in steel dates back at least as far as 1897. Among other things Escard repeated nearly ten years ago a report that Krupp used uranium steel in armor plate, and there have been various rumors that Germany is using uranium-steel liners in big guns in the present war.

In the United States commercial use of uranium steel is quite recent. According to a statement by R. M. Kenney in the "Mineral Industry" (1915), a high-speed steel showing excellent cutting qualities contained C, 0.078 per cent; Mn, none; Si, 0.16 per cent; P, 0.02 per cent; tungsten, 8.15 per cent; Cr, 3.62 per cent; vanadium, 1.18 per cent; and uranium, 1.02 per cent.

While uranium steel has been widely advertised as the last word in high-speed to tool steel, the reports of Hoffman and Johnson were not so favorable, the former stating that a uranium steel with 5 per cent tungsten and 3 to 4 per cent Cr made a very good tool and did good work for, say, two grindings. After that it did not hold its efficiency and had to be rehardened. Johnson stated that a 40-point carbon steel with 0.3 per cent uranium was disappointing, being red-short at ordinary forging heat and altogether uninteresting from a practical point of view. Therefore, in the opinion of present writers, all that can be said now is that uranium deserves a careful trial, both in tool steel and in ordnance, though the former is probably the more promising field.

As regards the composition of the so-called uranium steels, Johnson states that he has encountered ferro-uranium containing 15 to 20 per cent aluminum and that vanadium was always present from 2 or 3 per cent to 28 per cent; he stated also that one ferro-uranium analyzed by him contained 15 per cent silicon.

The price of American ferro-uranium in February [and April—Ed.], 1917, was $7.50 per lb. of uranium content. Partly on account of the price, experiments on uranium steels seem to have been confined to those with the maximum of

about 1 per cent uranium. It would be desirable to try it out with a percentage of 10 to 12 per cent, similar to that of tungsten in tungsten tool steels, even though such a steel may not be commercial.

The article further discusses in detail the method of production of uranium steels, in particular in an experimental furnace. (Paper to be read at the Kansas City Meeting of the *American Chemical Society*, abstracted through the *Journal of Industrial and Engineering Chemistry*, vol 9, no. 4, April 1917, pp. 343-347, *ge*)

Influence of Gases in Cast Metal, J. E. Fletcher

Practically the only thing known about the constituency of molten cast iron and steel is that they must contain in solution iron, carbon, silicon, manganese, phosphorus, and sulphur, but it is not exactly known how these metals and metalloids occur when in the liquid state. The iron-carbon alloys solidify first and are followed by others in ordered succession. In cast iron, for example, there is a constituent which is a metallic mixture of iron carbide and iron known as the eutectic containing 4.3 per cent of carbon, and also another similar constituent containing 0.9 per cent of carbon and known as the eutectoid pearlite.

The author has made many experiments in the way of quenching various carbon-iron and other alloys from the molten state and believes that there are definite structures even in the liquid metal itself. Further, he considers it as certain that the 4.3 per cent carbon eutectic can be superheated to 1500 deg. cent., which is the melting point of iron, and on being quenched will still reveal under the microscope a characteristic stratified honeycomb structure. The silico-ferrite crystallites under such circumstances are small, but of the characteristic fir-tree or dendritic structure.

The gases are imprisoned or dissolved in all molten metals and in cast iron and other eutectic-containing metals or alloys. These gases are very probably the formative or directive element in the growth of a honeycomb-like formation of the primary eutectic. The flow-line structure always having a direction towards the upper and hotter portions of the freezing mass of a eutectic ingot, gives the impression of fine gas streams set in motion by conventional forces, just as the streams of steam bubbles are given conventional flow in a boiler. It may be that the primary gas streams in flowing through the semi-liquid carbide of iron plate-like crystals make the paths through which the more or less carburized ferrite enters and freezes, such freezing action being immediately followed by that of the carbide.

The structure of a cast iron in the opinion of the writer must have some relation to the primary structure it received in the blast furnace. While the ores are being reduced the iron oxides are attacked by the carbon monoxide gas which is both the principal reducing agent and the chief carburization medium. This produces the spongy, porous nature of the reduced iron and may be called the first stage of the gas-absorbing tendency of the iron. The hydrogen which is also imprisoned by this action comes from the moisture evaporated from the blast ores, flux and fuel.

In the study of the gas influence the principal use of the microscope is in tracing the difference in crystalline structure between the outer rapidly cooled and the inner slowly cooled zones of a casting. If the cooling curves are taken simultaneously at each of these zones, in many cases the difference in the freezing behavior with its action of the phenomena of shrinkage and contraction may be observed.

Just previous to freezing of cast iron or steel the liquid metal may be conceived to consist of an agglomeration of liquid particles or crystals of various constituents of iron and manganese. The crystallites of partly carburized iron first separate out and freeze at the molten surface and at right angles to it. Almost immediately afterwards the silicide of iron freezes around the iron crystallites and these crystallites, as they freeze, eject their occluded gases into the mother liquor or eutectic. As the iron or silico-iron crystallites elongate and grow laterally the gases are driven inwards. The volume of any such partially frozen portion of the metal is as follows: Primary crystals A + mother liquor B + ejected gases C. As A increases, B decreases, while C simultaneously decreases. In cast iron the mother liquor B contains the segregates, slags, oxide and sulphide particles, together with the graphite flakes

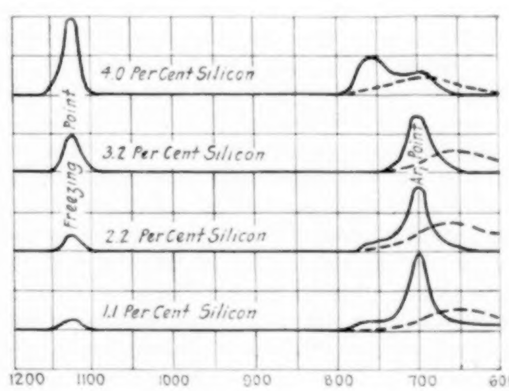


Fig. 3 Dilation of Cast Irons (Dotted Lines 2% Mn)

which escape with the gases into the hot fluid portions, which, when frozen, contain the highest percentages of these impurities. The gases thus liberated travel to the hot zones in the castings which are the last to freeze, and if there is no way for them to escape produce gas cavities or pipes.

The writer raises the question whether the phenomenon of shrinkage is connected with the volume of occluded gases, or rather with that of gases escaping during the freezing of iron and steel, and finds many evidences in favor of the latter conclusion.

Such is the case of a mild-steel block which was cast from a ladle of well-melted steel held in the ladle accidentally until close on the point of setting or congealing. The nozzle gave out and allowed scarcely any steel to rise in the casting head or riser. When cold the block was found to have contracted less than 1/16 in. per ft. The metal when planed revealed no pipe or cavity and was free from blowholes, while the weight of the casting indicated soundness. This case points to the fact that the gases escape freely during the slow rising of the steel in the mold, and that the occluded gases finally remaining in the metal mass were in a fine state of entanglement between the crystals uniformly throughout the mass. A similar casting made in the same heat from a more fluid steel piped deeply in the rising head and contracted normally at the rate of 0.2 in. per ft.

Whenever castings are made in chilled molds there must be shrinkage or contraction. Under such circumstances rapid freezing has a tendency to form small primary crystals which become quickly interlocked, imprisoning small gas bubbles. The cooling of the mass causes a shrinkage of the gas bubbles and it has been concluded that each gas globule occupies much less volume at 60 deg. fahr. than at 2000 deg. fahr.

From this the author proceeds to the discussion of the volumetric change during the freezing and later cooling of iron, as dependent on the analysis of the heat.

He bases his discussion mainly on the work of Professor Turner in this country.

Of interest is the part of the discussion referring to what happens at the point of recalescence. At that point there is another expansion (the primary expansion occurs at the moment of freezing) generally connected, as Professor Turner suggests, with the liberation of more free carbon, or temper carbon, and probably with the further increase in the volume of the gases as a result of the heat evolution which then takes place.

Baker in his experiments on the quantity of gases drawn off from iron and steel heated in a vacuum, decided that the greatest quantity is ejected at the recalescence point, thus confirming the work of earlier investigators. More recently Charpy concluded that the expansion or dilation of carbon-iron-silicon alloys was increased at the freezing point as the silicon content rose, while the expansion at the recalescence point is diminished, as is shown by the curves in Fig. 3.

This conclusion confirms experiments made by the author on cast irons with varying silicon contents, in which it was found that manganese and silicon together intensified such action. Generally speaking, white irons shrink most. The more highly silicious irons shrink last. But it would seem that whenever the iron carbide in either the primary crystals or in the eutectic is retained, as is the case when manganese or chromium is present, the speed of freezing is increased, and the gases liberated are driven rapidly into the more fluid portion of the metal mass, where there is a tendency to form shrink cavities. In low-silicon irons, free from phosphorus, high manganese generally produces such results, especially if the casting temperature is low. The presence of phosphorus is an aid to gas escape into the hot interior of a cooling casting.

The question of hot-casting is allied with the problem of shrinkage and of gas exit. Generally speaking, when the metal is cast hot there is a better distribution of the gases which remain in the cold metal and less risk of blowholes and cavities.

Hot-casting is especially important in the case of pure irons of hematite and cold-blast character low in total carbon, phosphorus and silicon. Such iron cools and shrinks rapidly, because its primary crystals freeze at a high temperature, and the mother liquor being purely eutectic also freezes rapidly.

The author calls attention to the fact that the importance of taking into consideration the influence of gases in the foundry problem can scarcely be underestimated. The major portion of foundry troubles are associated to a certain degree with the question of occluded gases. (Paper presented at a meeting on November 27, 1916, of the Birmingham Branch of the *British Foundrymen's Association,* abstracted through *The Iron Trade Review,* vol. 60, no. 11, March 15, 1917, pp. 617-621, 9 figs., *et*)

BORONIZED METALS, James Scott

Boron, which has an atomic weight of 10.9, is an element which, like carbon, is allotropic. It has a strong affinity for oxygen and may, therefore, be used as a deoxidizer. Boric acid (BO_3) has a remarkable property that when dry it can be heated to a high temperature without vaporizing, but when dissolved in water it readily passes away in the steam produced by boiling. From this it appears that its ability to prevent the development of blowholes is due to this refractoriness. It not only fails to generate cavities itself, but in some way attracts fumes which might otherwise get imprisoned in solidified metal.

The author microscopically examined the three more important boron alloys, namely, aluminum, copper, and copper-nickel.

The superficial texture of these alloys is shown in the original article in magnified microphotographs.

The form in which boron is now used for the purification of metals is as a fluoride. (*The Metal Industry,* vol. 15, no. 3, March 1917, pp. 115-116, 3 figs., *de*)

Foundry

THE AMERICAN FOUNDRY IN TIME OF WAR, Edgar Allen Custer, Jr.

The writer discusses in a general manner the conditions which American foundries had to meet when the European demand for munitions arose in this country, and the further conditions for which they should be ready with the United States itself facing the problem of war.

The production of cast-iron or semi-steel shells presents difficulties that heretofore few, if any, foundries have been called upon to meet. The range of physical qualities is limited to almost one precise point that will give the proper fragmentation, and it is essential to obtain and maintain this point. Too great a resistance to the bursting effect not only reduces the number of fragments, but necessarily reduces the destructive capacity of the shell, since too great a proportion of the explosive effort is needed to effect the bursting; on the other hand, insufficient resistance results in excessive fragmentation in which the pieces are so small that they are not capable of serious damage.

In addition to this, a sound casting is absolutely essential, not only because unsoundness tends to interfere with proper markmanship, but still more because of the possibility of a weak spot giving way under impact in the gun which may result in tearing the gun to pieces.

These strenuous conditions call for a most exact method of procedure. The chemical analysis of the heats must be not approximate, but exact, and it is significant that 75 per cent of rejections in French factories, while endeavoring to produce satisfactory semi-steel shells, could be traced directly to faulty analysis of the mixtures. To successfully produce semi-steel shells designed for active service the foundrymen cannot rely on approximations or the analysis of the irons guaranteed by a salesman, but must use the services of a chemist.

The next point of importance is the management of the cupola. The method of laying, lighting, and burning up a fire should absolutely eliminate the possibility of a poor start, for such a start may spoil the whole heat. Thus a poor start may mean that quite a proportion of the first metal charged is melted at a temperature below that necessary to produce satisfactory semi-steel. This may result in as much as 20 to 30 per cent of the heat being unfit for use.

The work of weighing and charging must be executed carefully and not left to the discretion of the laborer on the platform. Too often the given quantity is measured as average pigs, or so many buckets or forks of coke, and generally some more for good measure. Such a method of cupola operation is sufficient to set at naught any close or active work on the part of the chemist.

The melting temperature should be kept as constant as possible and at a point slightly above normal. Semi-steel like

cast iron will absorb or throw off impurities according to its melting temperature. In handling the metal it was found that the best results could be obtained by using a specially constructed receiving ladle under the spout of the cupola.

Second in importance to the chemical analysis and the means of obtaining it, comes the molding of semi-steel shells. According to one report a foundry in northern France failed to produce a single satisfactory heat until green-sand molding was abandoned. Too much attention cannot be paid to the use of the trap gate in molding with semi-steel, especially on shells. The position of the casting when poured gave considerable trouble when the French factories first started on semi-steel shells. At first it was considered necessary to pour the casting on end and to allow extra metal on the cope to collect dirt and gas holes and to provide metal for possible shrinkage, but later on the vertical form of molding was largely discontinued, and this permitted the use of the match-plate form of machine molding and molding the shells in pairs, using a balanced core.

Among other things discussed in the article are the methods of taking samples of metal, analysis and inspection of the product. (*The Foundry*, vol. 45, no. 294/4, April 1917, pp. 127-130, *p*)

Fuels and Firing

The Permeability of Coal to Air and Gas and the Solubilities of Different Gases in Coal, J. Ivon Graham

A knowledge of the permeability of coal to air or gas is important for the comprehension of the processes of spontaneous heating in coal and the production and discharge of firedamp and blackdamp.

In experimenting on the permeability of coal to gases, difficulty was at first experienced in obtaining a gastight seal between coal and any form of connecting tubes. The method finally adopted as most satisfactory was as follows: Thin slabs were sawn off from a large lump by means of a fine hacksaw. Some of the slabs were cut in the direction of the cleavage of the coal, others at right angles to it. Pieces of glass tubing ½ in. to 1 in. in diameter were sealed on each side of the slab. To obtain an airtight seal, the following method was adopted: The end of the glass tube previously warmed in a blowpipe flame was dipped into molten bitumen, such as is used for electrical insulation purposes, and a small quantity of bitumen in an almost molten condition was thus obtained on the end of the tube. The latter was then quickly pressed against the coal slab and held rigidly until the bitumen became quite hard. Successive thin layers of seccotine were next applied around the junction and allowed to dry. A second tube was then sealed on to the opposite side of the slab in a similar fashion. It was found that by this method a practically airtight seal could be obtained, sufficiently tight to hold a vacuum for several days.

In the case of "softs" it was found almost impossible to obtain a slab free from cracks, owing to the fragile character of this coal. In cannel, cracks also developed very rapidly. The majority of the results so far obtained, therefore, deal with slabs from "hard" coal.

The article describes in detail the methods of experiment followed with various gases, and presents in tabular form a summary of results. These results are quite remarkable, as they show that, contrary to the usual supposition, solid coal is extremely airtight and lets very little air or gas through, even with a driving pressure of a whole atmosphere. Carbon dioxide passes through the slab much more slowly than hydrogen, and to a similar extent the same may be said to be true of methane.

It was thought at first that the solubility of the gases, which is very high for carbon dioxide and methane, might affect the results for the initial stages for the flow of gas through the slab. It was found, however, that this is not so.

The writer proceeds to show how the results obtained affect the explanation that the heatings and fires which often occur in the walls of main roads driven through solid coal, commonly many years after the roads have been driven. These fires are ascribed to "breaks" in the coal which let in the oxygen. These breaks appear to be just as dangerous many years after the road has been made as with a freshly made road.

The article proceeds next to the description of experiments on the solubility of gases in coal, and in particular on the solubility of methane.

It has been found among other things that there is a considerable variation in the degree of solubility of various gases and that this diminishes in every case with rise of temperature. For the less soluble gases the amount dissolved is practically directly proportional to the pressure or concentration of the gas over the coal (practically Henry's law for the aqueous solution of gases). For the more soluble gases, as carbon monoxide, methane and carbon dioxide, "the amount dissolved—concentration of gas" curves deviated somewhat from a straight line, this deviation being the more evident the greater the solubility of the gas. In fact, the amount dissolved at low concentration of gas appears to be proportionately greater than that dissolved at high concentration.

Among other things the influence of the coarseness of the dust on the solubility of the gas has been determined, as well as the solubility of gases in finely powdered shale dust (*Trans. Inst. Min. Eng.*, vol. 52, pt. 3, February 1917, pp. 338-347, *e*)

Spontaneous-Ignition Temperatures of Liquid Fuels for Internal-Combustion Engines, Harold Moore

Flash points and burning points are common tests used for both liquid fuels and lubricating oils. These properties provide a measure of the danger from fire which is encountered in the handling and storage of the fuels, but are of little use as an indication of the behavior of a fuel in an internal-combustion engine. Such an indication, however, is given by the temperature of spontaneous ignition, which is the temperature at which a substance surrounded by oxygen or air at the same temperature will burst into flame without an application of any spark or other local high temperature.

The paper describes the experimental apparatus by which the spontaneous-ignition temperature was determined, and Table 2 gives the results obtained.

In a Diesel engine firing depends upon spontaneous ignition of the fuel immediately after it enters the cylinder. It is, therefore, necessary to employ high compression pressures in order to obtain a temperature high enough to insure the spontaneous combustion of the charge, but provided the temperature is obtained, it is advisable to keep the compression pressure low. Hence, the temperature at which the fuel will ignite spontaneously is of fundamental importance. By means of the formula

$$T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}$$

it is possible to calculate approximately the temperature to correspond to any given compression. In this formula T_2 and

T_1 are respectively final and initial absolute temperatures. P_2 and P_1 are respectively final and initial pressures, and n is a constant approximately equal to 1.35.

As an example of the influence of the ignition temperature of a liquid fuel the case of alcohol may be taken. It has been found in practice that alcohol, though much lower than gasoline in calorific power, when run in an engine can be made to yield approximately the same power per unit volume as gasoline.

TABLE 2 TEMPERATURES OF SPONTANEOUS IGNITION

Description	Specific gravity	Spontaneous ignition temperature, deg. cent.		Difference, deg. cent.
		in oxygen	in air	
PETROLEUM DISTILLATES				
Pratt's Perfection Spt. No. 1	0.710	272	383	+111
Petrol (Mex.)	0.718	279	361	+ 82
Pratt's Spt. No. 2	0.724	270	371	+101
Taxibus Spt. (A. A. O. Co., Ltd.)	0.729	272	399	+118
Paraffin Oil from A. A. O. Co	0.807	251	...	...
Petrolite Kerosene	0.814	251.5	432	+180.5
Empire Paraffin	0.782	253	395	+142
Petrol from Anglo-American	0.735	...	392	...
Gas Oil, A. A. O. Co., Ltd	...	254	358	+104
PETROLEUM (CRUDE AND RESIDUE)				
Crude Petroleum (Egypt)	0.851	260	...	...
Dijboi Oil (Assam)	0.890	261	384	+123
Anglo-Persian Oil Co.'s Oil	0.894	254	408	+154
Crude Petroleum (Texas)	0.895	256	387	+131
Anglo-American Fuel Oil	0.900	260	430	+161
Anglo-Mexican Oil	0.908	259.5	417	+157.5
Crude Petroleum (Texas)	0.936	268.5	416	+147.5
Crude Petroleum (Borneo)	0.939	269	380	+111
Mexican Fuel Oil	0.948	259.5	424	+164.5
Crude Petroleum (Mexican)	0.949	258	425	+167
Crude Petroleum (Trinidad)	0.950	274	424	+150
Crude Petroleum (California)	0.952	264	...	...
Venezuelan Petroleum	0.955	275	429	+154
Crude Petroleum (California)	0.961	262	420	+158
SHALE OILS				
Oil-Engine Oil (Bruxburn Oil Co., Ltd.)	0.768	253	333	+ 80
Lighthouse Oil (Bruxburn Oil Co., Ltd.)	0.803	251	322	+ 71
TAR DISTILLATES				
Xyloe Commercial	0.860	484	...	...
Toluol, 90%	0.863	516	...	...
Benzol, 100%	0.875	566	...	...
Premier Tarless (Tar Oil)	0.992	349	...	...
Creosote Oil (Harman & Holden)	1.010	415	...	...
Water-Gas Tar Creosote (Stainsby & Lyons)	1.036	473	...	...
Coke-Oven Tar Oil (Ximon Carves)	1.046	478	...	...
TARS				
Tar (Product of low temp. carbonization)	0.987	307	508	+201
C. W. G. Tar (Stockport Gas Works)	1.074	464	...	...
Oil Gas Tar (Beckton)	1.077	415	...	...
Horizontal Retort Tar (Heywood Gas Works)	1.114	445	...	...
Horizontal Retort Tar (Stockport Gas Works)	1.123	454	...	...
Coke-Oven Tar (Simon Carves)	1.132	494	...	...
Coke-Oven Tar (Copper Co.)	1.140	488	...	...
Coke-Oven Tar (Koppers Type Ovens)	1.145	495	...	...
Blast-Furnace Tar (Carlton Iron Works)	1.172	498	...	...
Blast-Furnace Tar (Wm. Baird & Co.)	...	410	...	...
MISCELLANEOUS				
Alcohol	0.817	395	518	+123
Turpentine	0.842	275	275	same
"Mirrlees-Diesel" Compressor Lubricating Oil	0.875	265.5	405	+139.5
"Mirrlees-Diesel" Engine Lubricating Oil	0.894	265.5	410.0	+135.5
Whale Oil	0.921	273	470	+197
Ether	0.730	190	347	+157
Paraffin Wax	...	245	...	...
Naphthalene	...	402	...	...
Free Carbon from Tar	...	348	...	...
Asphaltum from Oil	...	260	...	...

The net calorific power of gasoline is about 10,450 calories per gram, or 7315 cal. per cc. The net calorific power of commercial alcohol is about 5420 calories per gram, or 4440 cal. per cc. If both be burnt in an engine with the normal compression (i. e., compression adjusted to suit gasoline), the consumptions per b.hp-hr. will be approximately in inverse proportion to the calorific powers of the fuels, and over $1\frac{1}{2}$ gal. of alcohol will be required to do the same work that 1 gal. of gasoline will. Now, the spontaneous-ignition temperature of gasoline (in oxygen) is about 272 deg. cent., while that of commercial alcohol is 395 deg. cent.; therefore alcohol will withstand a much higher compression.

The compression pressure of a gasoline engine tuned to run on gasoline is approximately 90 lb. per sq. in., but with alcohol this pressure may be raised to 200 lb. per sq. in., and by this means the overall thermal efficiency of the engine is raised from about 22 per cent to 35 per cent, when it is found that the volumetric consumption of alcohol per brake horsepower-hour is approximately the same as that of gasoline. Thus though gasoline possesses 65 per cent greater calorific power than alcohol per unit volume, the advantages of this high heat value are entirely lost on account of its low ignition point. The ignition temperature is of general interest to chemists, as it is a measure of the relative stability of the bodies towards heat. The accompanying table shows the spontaneous-ignition temperatures of several fuels which have been determined with the instrument described in the original article.

From general observations the author has concluded that:

1 Compounds containing simple molecules have higher ignition points than similar compounds containing more complex molecules. This rule applies to all types of compounds.

2 Ignition points of aromatic compounds are much higher than those of alipathic compounds.

3 Saturated hydrocarbons have lower ignition points than the corresponding saturated hydrocarbons.

4 Ignition points observed in air are higher than those observed in oxygen. This difference for petroleum products is generally 100 to 200 deg. cent. (*Journal of the Society of Chemical Industry*, vol. 36, no. 3, February 15, 1917, pp. 109-112, 2 figs. *eA*)

Internal-Combustion Engineering

THE USE OF KEROSENE IN GASOLINE ENGINES INSTALLED IN THE FORTIFICATIONS OF THE UNITED STATES, Capt. Charles O. Schudt and First Lieut. John W. Wallis, Coast Artillery Corps, U. S. A.

The writers do not believe in the possibility of the use of alcohol in such engines, and therefore limited their tests to kerosene only. These tests were carried out in the laboratory of the Coast Artillery School, and were made on the following engines:

Lathrop single-cylinder, two-cycle marine engine
Ferro single-cylinder, two-cycle, three-port portable engine
Engine attached to 5-kw. generating set; this is a four-cylinder, four-cycle stationary engine
Similar but larger engine attached to 25-kw. generating set.

The test with the Lathrop marine engine gave rather perplexing results. The engine had been operated many times previous on gasoline, using the Prony-brake load at a speed

of about 380 r.p.m. When the fuel was changed to kerosene the operation was not satisfactory.

The governor was then adjusted to give a speed of 525 r.p.m. without any change in the needle valve, or without intake spring when a load of 33 lb. at a radius of 24 in. was registered at the brake. The fuel was then changed to kerosene while the engine was running, and the speed immediately went up to 550 r.p.m., while the load on the brake arm remained at 33 lb. With the same adjustment, the engine, for a considerable time, carried a load of 40 lb. on the brake arm.

In subsequent tests after the fuel was changed to kerosene, the speed drop became erratic and the engine finally stopped. It appears, therefore, that this engine could be operated on kerosene only by very skilled operators.

It is probable that the principal reason for the failure of this engine to operate more satisfactorily is that it has an excessive crankcase clearance, resulting in low crankcase compression and permitting the fuel to separate from the air and settle while the mixture is in the crankcase. That the fuel immediately separates from the air is proven by the fact that it accumulates very rapidly in liquid form in the crankcase.

In the case of the four-cylinder, four-cycle stationary engine attached to the 5-kw. generator set, it was found that the operation of kerosene was quite successful, the behavior of the engine not being materially different from its behavior when operated on gasoline. Apparently, the only necessary change in the adjustments of the engine when the fuel was changed to kerosene was approximately to double the opening of the needle valve.

A supplementary test was run on a two-cylinder, four-cycle Standard marine engine of old design with a long, exposed intake pipe. Notwithstanding this latter feature, its operation on kerosene was entirely satisfactory. In fact, the change to kerosene fuel (the needle-valve opening was increased 50 per cent) was accompanied by a material increase in speed and brake horsepower. To determine whether the engine would "idle" satisfactorily on kerosene, it was operated for fifteen minutes without compression released and spark fully retarded. At the end of this time the load was thrown on, but one cylinder missed, and the engine would not come up to speed until a little gasoline was squirted into the air intake. This gasoline caused the missing cylinder to resume firing immediately, and the engine came up to speed. The exhaust smoke was fairly clear, indicating that the combustion was good, and consequently little probability of carbonization troubles.

From the limited tests conducted, it is believed entirely practicable for the enlisted specialist now in charge of these engines to operate them without very much difficulty.

One of the important things encountered in the tests was the mechanical inaccuracy of the valve timing. The valves in these tests were timed in the manner prescribed, and the setting was then checked on the flywheel. The angle past center at which the exhaust valves opened varied 9 deg. and the intake valves varied 7 deg. It is true that at this time the piston has very little motion, but this error in the cams causes trouble with kerosene fuel.

At no time was there trouble from knocking due to preignition. Curiously, knocking was accompanied by the best combustion; in other words, when all or most of the cylinders were knocking the exhaust was nearly clear. Knocking could be increased by shutting the needle valve. The influence of velocity of flame propagation is also discussed in detail. (*Journal of the United States Artillery*, vol. 47, no. 1, January-February 1917, pp. 24-35, *e*)

Machine Parts

Piston Design with Special Reference to Aluminum Pistons, Harry R. Ricardo

General discussion of design of pistons for internal-combustion engines of high output, and description of a "slipper" type piston.

The author establishes the general conditions with which a piston of a high-speed internal-combustion engine must comply, and calls attention to the fact that piston friction depends almost wholly on the viscosity of the oil, proved by the variation it undergoes with difference of temperature of cylinder walls. He reproduces a set of three curves of mechanical losses in a four-cylinder Daimler engine that was tested by Professor Hopkinson at Cambridge University.

In this engine piston friction at the higher speeds formed nearly 80 per cent of the total mechanical loss, and its susceptibility to changes of temperature is clearly shown. In another test recently made by the writer on a single-cylinder experimental engine, it was found that the mean pressure required to overcome piston friction varied from 18 lb. per sq. in. when the cylinder was quite cold to only 6 lb. per sq. in. when the jacket water was boiling.

The assumption that the friction loss in the countershaft and crankpin bearings is greater than that of the piston has been disproved by numerous experiments; the explanation of the fact that it is actually very much less appears to be that, although the same oil is used in both cases, the piston lubricant is largely contaminated by partially carbonized oil and its viscosity enormously increased in consequence. The carbonizing and thickening of the piston lubricant is mainly (but not entirely) due to the leakage of burned gases past the piston rings. In some cases this difficulty has been partly obviated by providing immediately below the lowest piston rings a recess having a number of holes drilled through it, so that any gases that succeed in passing the piston rings can escape freely into the crankcase.

As a matter of fact, a trunk piston has to perform two separate functions. The upper part of the piston is required to retain and transmit the gas pressure and distribute and dissipate the heat. Hence it should be made strong enough to withstand the pressure and thick enough to transmit the heat; also it should not bear against the cylinder walls, or receive any of the side thrust from the connecting rod. The piston rings should be relied on to keep it gastight, and since any oil which passes above the lowest piston ring will, of necessity, be carbonized, it should receive as little oil as possible, consistent with the maintenance of the piston rings and mechanical conditions of operation.

The lower portion of a trunk piston performs the duty of a crosshead and takes the side thrust from the connecting rod. Hence it should be fitted as closely to the cylinder as is consistent with the expansion and distortion that takes place, should be freely lubricated, should have as little bearing surface as is consistent with the loading and temperature, and the oil should be kept clean by allowing a free escape of any burned gases that may pass the ring.

Since the bulk of the losses is caused by the continuous shearing of oil film, it is important to reduce the surface to the lowest safe limit; while, as a rule, bearing surface is provided around the entire circumference of the piston, it is needed only around a small arc on either side of it. The bearing surface around the two sides of the piston which receive no thrust is particularly objectionable on account of

the local distortion set up with the great mass of metal in the gudgeon-pin bosses and by the bending of the gudgeon pin.

The proper way is to regard the lower part of the piston as a crosshead and design it as such; that is, provide it with just sufficient bearing surface in just the right place, have it freely lubricated and safe from the passage of burned gases between its bearing surface and the cylinder walls.

It is also desirable to perforate the bearing surface with a number of large holes, for when two freely lubricated surfaces are sliding over one another the oil between them is, so to speak, rolled up and heavy hydraulic pressure set up, and this can relieve itself by escaping through these holes.

As regards the design of the gudgeon pin, the writer believes that it is preferable to use a short and stiff gudgeon supported directly from the crown of the piston and by points as near to the ends of the connecting-rod bush as possible.

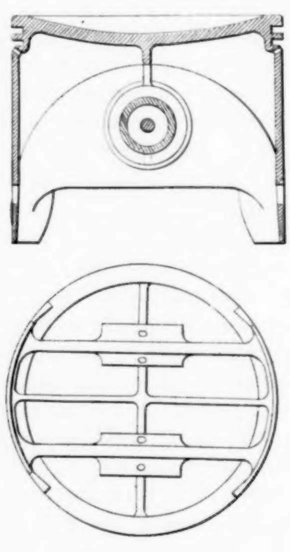


FIG. 4 EXPERIMENTAL DESIGN OF ALUMINUM PISTON

The loading on the gudgeon-pin bearing in a high-speed engine is not as severe as is generally supposed; providing the bearing is kept reasonably cold in order to maintain the viscosity of the oil, and the pin is well supported and stiff enough, it is perfectly safe to use bearing pressures vastly in excess of those now employed. Under these conditions a total projected area equal to 7 per cent of the piston area is amply sufficient for an engine running up to 3000 r.p.m., if the gudgeon pin is not more than 20 per cent of the diameter of the piston.

In the writer's opinion the best method of all is to float the gudgeon pin; that is, allow it to rotate freely in bearings, both in the piston and connecting rod, so that the rubbing velocity in each bearing is reduced to one-half. Under these circumstances the piston and the connecting-rod bearings may be reduced to 5 per cent, and that of the bearings on either side to 3 per cent with safety. The use of a floating pin has the further advantage that the difficult problem of fixing the pin and the risk of distorting both the pin and the bosses is obviated, but it must not be used unless the bosses are supported directly from the crowns of the pistons.

As regards the general design of steel pistons the writer describes two recent types, viz., the Sunbeam and the Zephyr. The aluminum piston affords a greater freedom of design, since ribs may be used with very little fear of distortion, and without adding perceptibly to the cost of manufacture. The necessary surface required to carry the side thrust from the connecting rod can be provided exactly where it is needed, and there only, in addition to which a short and stiff gudgeon pin can be used without necessitating long and heavy bosses.

In Fig. 4 is shown a design of piston which the writer has been using recently, and which is probably only suitable for aluminum pistons.

The particular features are that the vertical load is transmitted directly from the crown of the piston to the center of the gudgeon-pin bosses, so that a light gudgeon pin can be used without risk of bending. The horizontal thrust from the connecting rod is transmitted directly to the bearing surfaces and is distributed over them by means of two transverse ribs. Bearing surface is provided in the form of two slippers, so that the surface of oil in shear is reduced to a minimum, leaving an ample bearing surface. No load is transmitted through the side walls or past the piston-ring grooves. The surfaces of the two slippers are perforated to release the oil and the lower piston ring acts as a scraper ring; on the two sides of the piston where there is no bearing surface the scraper ring can prevent the slippage of oil almost completely, since it has to deal only with the oil adhering to the cylinder walls and not with oil under pressure. The weight of the piston is very low; for cylinder bores ranging from 3.5 to 5 in. in diameter the weight of the piston complete with gudgeon pin and piston

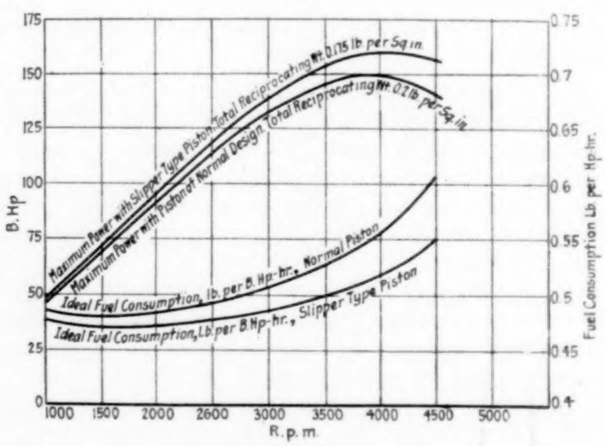


FIG. 5 POWER AND FUEL CONSUMPTION, VARIOUS PISTONS

rings can be brought down to 0.1 lb. per sq. in. of piston area. Several pistons of this weight have been in operation for some considerable time in high-speed engines and have proved themselves to be perfectly reliable.

Fig. 5 shows a gain in power and fuel consumption to be obtained by the use of these pistons, which is ascribed to the reduction in mechanical losses. It seems probable from examination of some of the pistons which have been in operation for many months that the bearing surface might be still further reduced with perfect safety. After long runs on full load the bearing surface was found to be profusely lubricated, with the oil showing no signs of discoloration due to carbonization. Experience has also shown a reduction in the oil consumption; in one extreme case it fell from 0.06 lb. per b.hp-hour to 0.035 lb. per b.hp-hour with no other change except in the pistons. The fuel consumption dropped 4 per cent, while the brake horsepower increased by about 4 per cent. (*The Automobile Engineer*, vol. 7, no. 100, March 1917, pp. 60-63, 7 figs. *te*)

Gearing Development Through Heat Treatment, W. H. Phillips

The author attempts to show how the development of heat-treating as perfected for automobile gears may be usefully applied to the case of rolling-mill gear trains.

If by increasing the cost of gearing from 25 to 50 per cent a gear is produced that will triple the life of the untreated gear, and at the same time eliminate breakage, there can be no doubt of its economy.

The writer mainly considers carbon-steel gearing and divides its treatment into three general classes: oil treatment, case hardening, and special treatment, with particular reference to the last one.

He emphasizes the fact that poor heat treatment is worse than no treatment at all, and insists on the necessity of an exact method of procedure checked by accurate temperature-recording instruments and facilitated by a closely regulated furnace.

In addition, one or more gears in every lot of one hundred should be taken for physical test. Since, however, even this does not necessarily insure uniformity, the Brinell hardness test may be used as a check on each gear.

Extensive experimentation has shown that by slight changes in the constitution of the metal a combination can be obtained which, when subjected to a special treatment, will produce physical properties peculiarly adapted to gearing. The hardness at the surface of the steel is from three to four times that of untreated steel, and grades off slightly toward the center of the tooth until it is from two and one-half to three times as hard as untreated steel. This reduction in hardness is in a straight-line ratio, and each fiber of the steel from the surface to the center or neutral axis of the tooth—which may be slightly to one side of the geometric center—will be stressed in proportion to its ability to carry the load, so that when the tooth receives a blow or shock every fiber is carrying its share of the load.

The effect of dynamic blows on spur gearing when running at high speed and transmitting heavy loads has never been accurately ascertained, but is known to be great, often excessive, and in such service forged steel should always be used, whenever possible. (*The Blast Furnace and Steel Plant*, vol. 5, no. 4, April 1917, pp. 152-154, *gp*)

Special Cams in Aluminum Engines of Premier Car, A. L. Nelson

The writer points out the gradual degrees of clearance between the tappet and cam in the valve mechanism. The reason for this reduction of clearance is that the motor speeds have been greatly increased and the standard of quietness of valve operation has been raised.

The clearance between the end of the rocker-arm lever and the valve stem of the aluminum motor with valve-in-the-head construction and camshaft in the crankcase is a matter of particular importance. The vertical expansion of the aluminum cylinder case is about twice as great as that of cast iron. Hence with the conventional type of cam adjusted with the valve-stem clearance at the working temperature of the motor that would give satisfactorily low valve-closing and lifting velocities, all the valves would be held open when the motor was cold.

It was found by experiment that the valve-stem clearance had to be at least 0.013 in. in order that the valves would retain sufficient clearance to start a cold motor, but with this clearance and the conventional cam the valves opened and closed at such high velocities that the valve action was entirely too noisy. In addition, impact on the valve seats and on all the valve-mechanism parts made the wear very appreciable.

It therefore became necessary to change the method of operating the valves by designing a new cam.

Fig. 6, upper half, shows the conventional cam contour, while Fig. 6, lower half, shows the new one. The new cam is virtually the conventional one with 0.020 in. taken off the diameter of the base circle and with a tangent drawn from a point to the new base circle. The time of opening the valve is made earlier for special reasons. Lift of the valve for the added angle is only 0.004 in., while the angular increase is 3 deg. 52 min. That is, the first part of the lift is so slow that

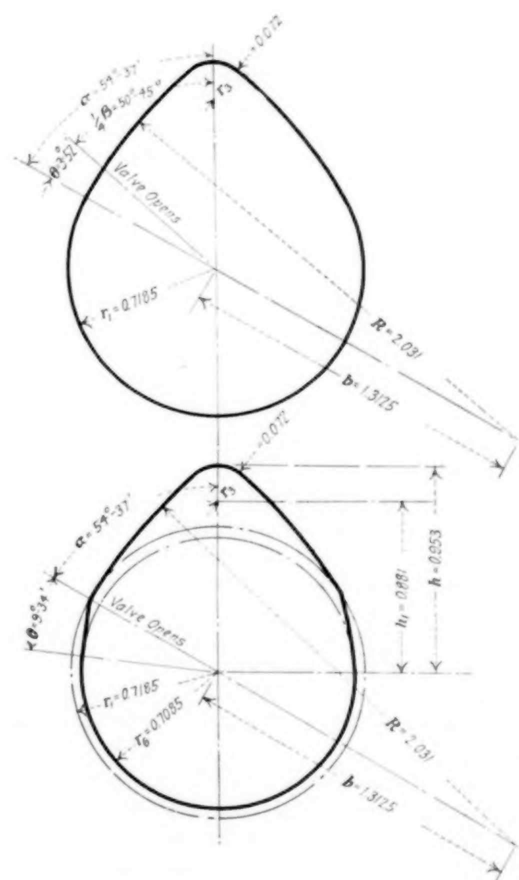


Fig. 6 Standard and Altered Cams for Automobile Engines

the valve has to be given an earlier start corresponding to the back-lash angle of the old cam.

As the valve-stem clearance increases by wear, the timing works towards the desired theoretical conventional timing and then past it instead of always away from it as in the conventional method.

An interesting feature of the design of the new cam is such an adjustment of the valve stem as to obtain an opening and closing of the valves at a cam position giving practically zero velocity at any speed.

From this the author proceeds to the mathematical analysis of the action of the new cam motion, viz., analysis of mushroom follower motion equations for the upper motion, and characteristic curves of the new cam. (*The Automobile*, vol. 36, no. 14, April 5, 1917, pp. 689-692, 6 figs, *dtm*)

Measurement and Measuring Apparatus

Temperature Measurements in Bessemer and Open-Hearth Practice, George K. Burgess

The problem of temperature measurement and pyrometric control of furnace-casting and ingot-teeming temperature is shown, by a series of observations taken in several steel plants, to present no serious difficulties or uncertainties.

For this purpose the most satisfactory type of instrument is one of the optical pyrometers using monochromatic light and permitting observation from a distance of streams of metal.

It is shown that the necessary corrections to the observed optical-pyrometer readings for emissivity of metal and oxides to give true temperatures are sufficiently well known, but there may be uncertainty in the case of liquid slags.

For streams of liquid iron or steel the most probable value of emissivity to take, with a pyrometer using red light of wave length $\lambda = 0.65$ μ is $e = 0.40$, corresponding to a correction of 139 deg. for an observed temperature of 1500 deg. cent. The value of e for liquid slags is usually about 0.65, but varies with composition of the slag. A table of emissivity corrections is included in the text.

Determination of the temperature of the charge of bessemer converters is not deemed practicable by pyrometric methods.

The operation of the open-hearth furnace can be gaged by the pyrometer, it being possible to control readily the temperature of the roof and of the bath of metal and slag by observations taken through ports; and the temperature of the metal may be had at any instant, with a fair degree of exactness, by observation with the optical pyrometer of metal removed in a spoon.

The temperatures of the roof of an open-hearth furnace are shown to bear no necessary relation to that of the metal bath, which again is shown may have zones of considerable differences in temperature, depending upon the operation of the furnace.

The temperature of the roof of an open-hearth furnace, dependent upon the firing practice, may vary very rapidly and within wide limits, 1550 to 1750 deg. cent. The temperature of the open-hearth bath is usually kept between 1600 and 1670 deg. cent.

There appears to be a very remarkable degree of uniformity in casting temperature actually acquired by the melters in practice. Thus, for 10 consecutive bessemer heats the teeming temperatures of the ingots were all between 1500 and 1550 deg. cent., and a similar degree of concordance, although at slightly higher temperatures, was found in the open-hearth practice of several mills.

It is believed that a continuous, systematic following of the temperature, by the methods above outlined, for the various furnace and casting practices, on the part of steel and iron mills, would show the possibility of improvements and greater certainty of production in quality of product; also changes and the effects of variation in ingot or furnace practice could undoubtedly be carried out with greater certainty than at present appears to be the case. (*Bureau of Standards*, Technologic Paper No. 91.)

Pyrometers, Richard P. Brown

Brief historical discussion of methods of measuring high temperatures, followed by concise descriptions of modern pyrometers and methods of using them.

The writer describes in particular the use of thermoelectric pyrometers, with and without compensating boxes; the two methods of measuring the voltage produced by a thermocouple, namely, the millivoltmeter and the potentiometer methods; and finally, the use of the radiation pyrometer.

Methods of calibration of pyrometers are briefly described. The writer believes that the greatest feature in pyrometry is along the line of automatic temperature control, and calls attention to the fact that there have been already designed instruments capable of maintaining the temperature constant within 10 deg. fahr. He further suggests that the steel manufacturers, who are interested in the improvement of heat-treating methods, can be of great assistance to pyrometer manufacturers in coöperating with them to test out new devices in an endeavor to improve on present methods. (*The Iron Trade Review*, vol. 60, no. 12, March 22, 1917, pp. 671-673, *g*)

Mechanics

The Comparison of a Certain Case of the Elastic Curve with Its Approximation, R. W. Burgess

In the usual discussion of the elastic curve in elementary textbooks of physics and engineering, a certain term in the differential equation of the curve is neglected and the curve resulting from this approximation is said to be a good substitute for the real elastic curve. It is my purpose in this note to show by a comparison of one case of this approximate solution with the accurate solution, that the one is not always a satisfactory substitute for the other.

If a straight, thin rod in which I is the moment of inertia of a cross-section about a line perpendicular to the plane of bending, and E the constant of elasticity, is bent into a bow by two opposing forces each of magnitude H, acting at the ends of the rod, it is assumed, or deduced from more elementary assumptions, that the resistance to bending at any point is proportional to the curvature of the central axis at that point. The bending moment at any point is therefore proportional to the curvature; taking the central axis when unbent as the x-axis, and a perpendicular at its mid point as the y-axis, we have $Hy = EI/\rho$, that is, $\rho y = EI/H = a^2$, say, as the equation of the central axis. We can without difficulty integrate this equation, subject to the conditions $y = h$, $dy/dx = 0$ when $x = 0$. Substituting the known value of the radius of curvature in the equation $\rho y = a^2$, we obtain

$$a^2 \frac{d^2y}{dx^2} = -y \left[I + \left(\frac{dy}{dx}\right)^2 \right]^{3/2}$$

From this the author derives the common expression

$$l = \pi a \left[1 + \frac{h^2}{16a^2} + \dots \right]$$

The usual approximation is to omit from the original expression the term for the slope $(dy/dx)^2$, which is small if the bow is only slightly bent. The equation is then

$$a^2 \frac{d^2y}{dx^2} = -y$$

and the solution is $y = h \cos x/a$, which is said to be a good approximation to the solution.

Actually, however the author shows that for small deflections the error of this solution is nearly 100 per cent. He thinks therefore that the cosine curve, with h determined by a formula deduced from this equation, is not satisfactory, in any case where the length of the bow or column is one of the given physical constants. The difficulty is of course due to

the fact that deflection is of the same order of magnitude as the slope which was considered negligible.

Errors of this nature due to dropping terms from a differential equation probably exist in other physical problems; this one is unusual in that both the exact and the approximate equations can be solved in terms of known functions. (*Physical Review*, vol. 9, no 3, March 1917, pp. 193-197, *tm*)

Railroad Engineering

Pennsylvania Atlantic-Type Locomotive Tests, Andrew C. Loudon

The article describes the most recent form of Pennsylvania Atlantic-type locomotive, as well as the tests carried out at the testing plant at Altoona.

During the period of development of the Atlantic-type locomotive, experiment has shown that if boiler tubes are increased in length without any increase in diameter, there is a point beyond which the lengthening of a tube fails to produce a proportional increase in evaporation. For best results, the tubes should be extended fully up to the point where the increase in evaporation ceases to be proportional to the increase in length. It has been found on the Pennsylvania that the most desirable length for a tube is about 100 times its internal diameter, and this rule has been adopted, with a leeway to the designer of 10 or 15 per cent to satisfy other boiler conditions.

In the final form of the locomotive (E6s), the original 14-in.-diameter piston valve was replaced by a 12-in., which has been found to be practicable, because superheated steam flows through the steam passages with greater freedom than saturated steam of the same pressure.

The reciprocating parts are very light, and, although the maximum weight on a pair of drivers is now 67,000 lb., the dynamic augment at 70 miles an hour is less than 30 per cent of the static weight on the drivers.

The article describes the tests in detail. Because of lack of space only the outstanding features can be here reported.

The tests in this instance (No. 51) are throughout compared with previously published tests of the older type locomotive No. 89 (locomotives of the latter type are no longer in service).

Fig. 7 shows comparisons between the evaporations per pound of coal at all rates of evaporation. This shows improved results for No. 51 up to the maximum rate where the two lines meet. The maximum rate of equivalent operation for No. 51 is 17.22 lb. per sq. ft. of heating surface per hour.

The shorter-tube boiler showed a great activity of combustion for light drafts, but there was very little difference in the rapidity of evaporation in the two boilers until a draft of 5 in. of water was obtained back of the diaphragm. The shorter-tube boiler thus showed a more rapid rate until its evaporation limit was reached.

As regards engine performance, the efficiency tests made at the testing plant were at speeds between 28.1 miles per hr. (120 r.p.m.) and 84.4 miles per hr. (360 r.p.m.), the nominal cut-offs being between 15 and 50 per cent. At 75 miles per hr. and 35 per cent cut-off, the i.hp. was 2357.2, while in a second series of tests the i.hp. reached 2488.9, or 1 hp. for each 96.5 lb. of total weight.

The coal rate per i. hp-hour did not exceed 3.6 lb. in the first test, and was usually below 2.9 lb.

The steam consumption per i.hp-hour up to 1800 hp. was practically the same for both No. 51 and No. 89. The maximum steam temperature reached (in the branch pipe) was 635.7 deg. fahr., or 251.3 deg. superheat, but in general the superheat was below 230 deg. fahr. Considering the efficiency of the engine, and taking the Rankine cycle as a base for an ideal engine, it is found that the actual engines developed an efficiency which was 67.8 per cent of the ideal.

The maximum drawbar or dynamometer hp. obtained was 2250.5, with the coal rate of 3.8 lb. per dynamometer hp-hour and the steam rate of 19.8 lb. In the curves of the drawbar pull, Fig. 8, the advantage of the larger cylinders of No. 51 is in evidence, the greater drawbar pull being maintained by this engine at every speed up to 85 miles per hour. An interesting feature of the drawbar-pull tests is shown in Fig. 9. The straight lines show the drawbar pull at the various cut-offs given, and indicate a falling off in pull as the speed increases. It is believed that this effect is due to losses of pressure in the cylinder as the piston speed increases. (*The Railway Age Gazette*, vol. 62, no. 12, March 23, 1917, pp. 635-640, 12 figs. *eA*)

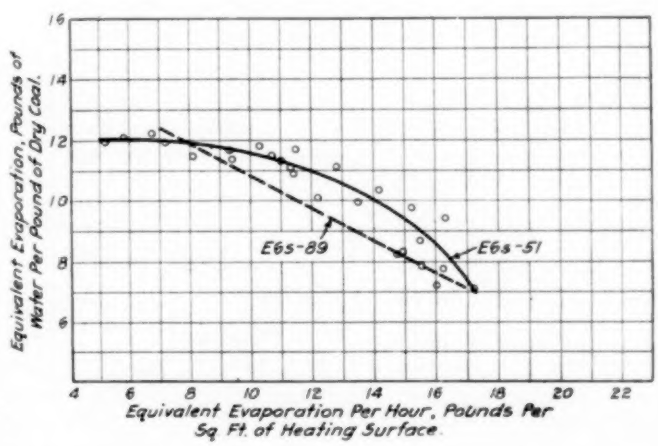


Fig. 7 Equivalent Evaporation Per Pound of Dry Coal

Refrigeration

High-Speed Ammonia Compressors, C. R. Neeson

The writer discusses the reason for using high-speed ammonia compressors and the main features of their design

In regard to the latter he states that the only type of valve feasible is one consisting of a thin plate of special steel to cover a series of slots in the valve cage, which gives a maximum opening with a very small lift, thus allowing a rapid movement of the valve without shock or noise. As the valves must be accessible they are placed radially in the cylinder body at each end, suction valves at the top and discharge valves at bottom. All valves are alike and interchangeable.

A new principle has been adopted in order to completely fill the cylinder to suction-pipe pressure. This is a series of ports around the center of the cylinder casting which are uncovered by the piston at the end of the suction stroke when its speed is least and its acceleration greatest, and where the inertia of the gas in the suction pipe tends to build up the pressure at the cylinder. The length of the piston is about the same as its stroke. As there are no valve springs to overcome, it is possible in spite of the so-called high speed to fill the cylinder to the exact pressure in the suction line. Several diagrams are shown to prove this statement. These diagrams show that the pressure in the suction pipe at the

beginning of the suction stroke is slightly above the pressure at accumulator, due to the inertia of a column of gas at high velocity that is stopped suddenly when the piston reaches the end of the stroke closing the suction valves. (*A. S. R. E. Journal,* vol. 3, no. 5, March 1917, pp. 15-29, 15 figs., *d*)

Composition and Testing of Commercial Liquid Ammonia, E. C. McKelvy and C. S. Taylor

The present paper is a progress report presented at the Twelfth Annual Meeting of the American Society of Refrigerating Engineers in December, 1916, published by permission of the Director of the Bureau of Standards.

As part of the work of the Bureau of Standards upon the determination of the physical constants of ammonia, especially those which are of importance in refrigeration, an investigation was undertaken, one of the objects of which was "the acquisition of the necessary information regarding the state of the methods of testing and analysis of liquified ammonia" in industrial use.

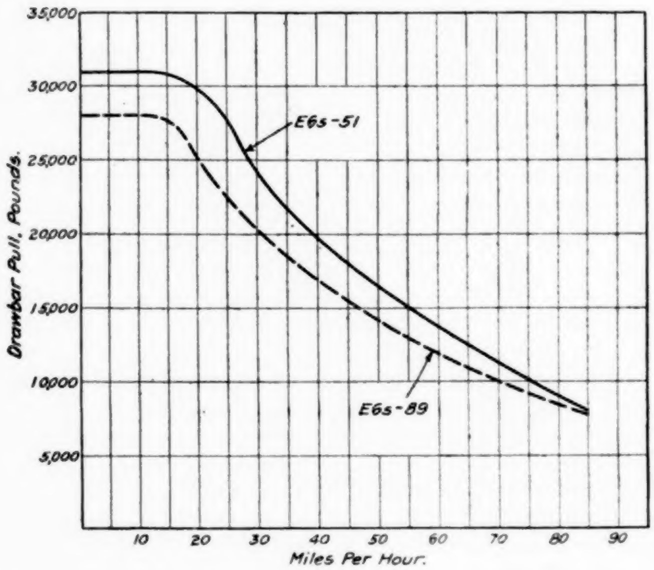


Fig. 8 Drawbar-Pull Curves

The present investigation covered the determination of the impurities in commercial ammonia, the methods of sampling, methods of analysis, and standards of quality.

As regards the composition of commercial ammonia, the results of the present investigation indicate that about two-thirds of the samples examined are about equally suitable as the starting material for the preparation of pure ammonia to be used in exact chemical and physical work.

The results of chemical analysis indicate the adequacy of the simple evaporation test as conducted in many works in detecting samples of poor quality, but such a test is useless in differentiating the majority of the samples now on the market.

The following tentative specification for liquid ammonia is offered. It is based upon determinations that can be carried out in the chemical laboratory, and will insure the delivery of high-grade material. In large shipments where the testing of each drum is out of question, only a general indication of the quality can be obtained by examination of the contents of a few drums chosen at random.

1 The gas drawn from the cylinder (gas phase) on the first opening must contain per 100 grams of ammonia not more than 30 cc. of non-condensing gas (gas unabsorbed by 0.2 N sulphuric acid).

2 The residue on free evaporation of the liquid ammonia, with due precaution for excluding moisture and contamination of the sample on drawing, must be not more than 0.03 per cent.

3 The amount of aromatic amines estimated as pyridine must be not more than 0.001 per cent; the amount of organic acids estimated as acetic acid must be not more than 0.005 per cent.

4 The total organic material converted into carbon dioxide must not give more than 30 milligrams of carbon dioxide per 100 grams of ammonia.

A brief bibliography is appended. (*A. S. R. E. Journal,* vol. 3, no. 5, March 1917, pp. 30-49, 2 figs. *ep*)

Latent Heat of Ammonia, Gardner T. Voorhees

Derivation by a new method of the values of the latent heat of ammonia.

The writer establishes in the first part of his article formulæ for the latent heat of ammonia or other similar substances.

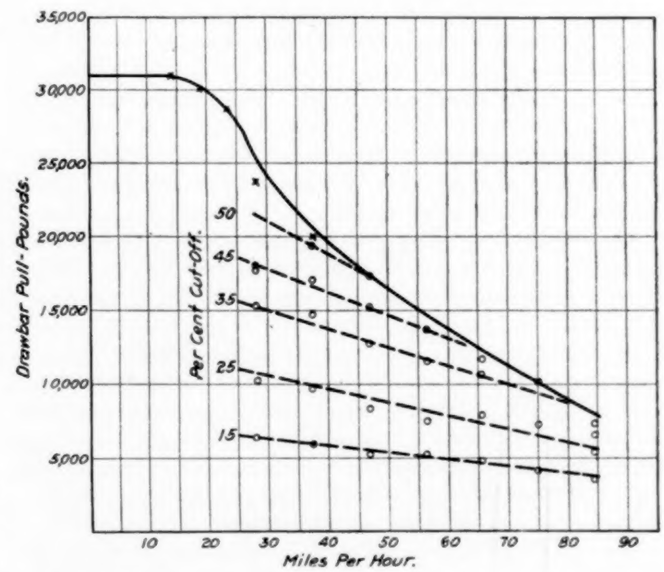


Fig. 9 Maximum Drawbar Pull at Various Cut-Offs

From this he proceeds to the derivation of the curves shown in Fig. 10. This work is substantially based on the data of tests made by Professor J. E. Denton, and published in Trans. Am. Soc.M.E., Vol. 12.

Professor Denton gives all the figures for his tests on brine meters and the ammonia meter, but uses a fixed coefficient. Since, however, the brine coefficient for brine meter will vary with the quantity, the present writer has surveyed coefficients from his actual meter tests, and thus obtained slightly different weights of brine circulated. Similarly, a variable coefficient has been derived and used for the ammonia meter.

Tests 2 and 4 of Professor Denton had estimated temperatures for the liquid to the expansion valve. The writer reëstimated these temperatures by a different method and deduced the same results as Professor Denton.

The heat balance as figured by Mr. Voorhees showed about 4 per cent for test 2, about 3 per cent for test 4, and about 3

per cent for test 8, more heat given to the ammonia than taken from it. A correction of less than a fraction of one per cent of the quantities involved was further made for the exposure of the condenser.

On the basis of the above considerations has been plotted on Fig. 10 the curve of high latent heats of condensation. The low latent heats of vaporization, figured by taking the difference in heats of liquid from the latent heat, are shown at 2, 4, 8*l* in the same figure.

Any peculiarities in the action of the ammonia would not have any material effect on the latent heat, and therefore the writer has averaged the three high latent heats and their corresponding saturated temperatures given as 2, 4, 8*h* in Fig. 10. Next the author applied two previously derived equations and has deduced therefrom the approximate latent heats for all conditions from the freezing point of ammonia to its critical temperature. The approximate curve of latent heat is not shown.

The average high-temperature latent heat as represented by point 2, 4, 8*h* of Fig. 10 is at 79 deg. and is 504 B.t.u., the value deduced from Denton's tests by the present writer for this latent heat.

The writer has also plotted a curve not shown here which is the average of the low-temperature latent heats deduced from Denton's tests and equal to 564 B.t.u. The low-temperature latent heat was below the curve above referred to. This occurred because the energy that was dissipated in passing the

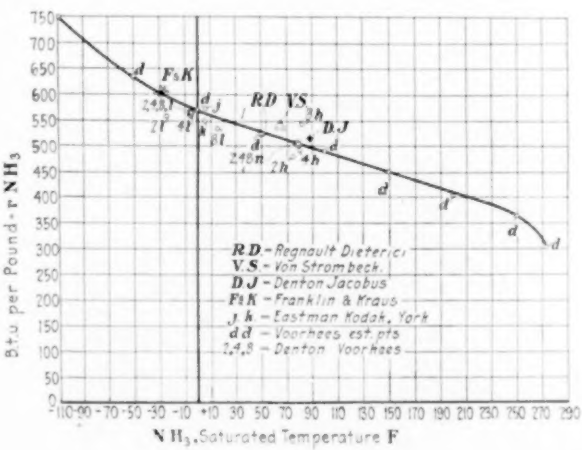


Fig. 10 Latent Heat of Ammonia (— 108 to + 273° F.)

expansion valve was not taken into consideration, and this energy is equal to the energy that we would have had, if we had had an expansion cylinder. This energy loss at the expansion valve is made up of two parts: First, the energy that would have been required to get the liquid back from the cylinder into compression chamber from the low pressure to the high pressure; and second, the work that would be required to saturatedly compress vapor formed at the expansion valve from the low to the high pressure, and push the resultant liquid back into the proper chamber. The writer gives formulæ for the loss of heat by dissipation at the expansion valve.

A still further important correction is suggested for the latent heats. Up to this point it has always been estimated that the evaporation at the expansion valve was due to the difference of heats of liquid, as if the latent heat used for so doing was entirely at the low pressure.

To determine this the writer deduced successive new curves with successively closer approximations to the true average latent heat, and continued this process until any further approximate curves would make less than 1 B.t.u. difference at any point. These points gave what is believed to be the true latent heat of ammonia as it would actually be in a practical refrigerating system, because its foundation is laid on actual, very accurate tests of a practical refrigerating system and the deductions therefrom based on what is believed to be sound thermodynamic reasoning.

These points have been plotted on Fig. 11 and joined with a smooth curve.

The article gives equations for useful refrigeration with an expansion-valve refrigerating cycle, and a table of figures on

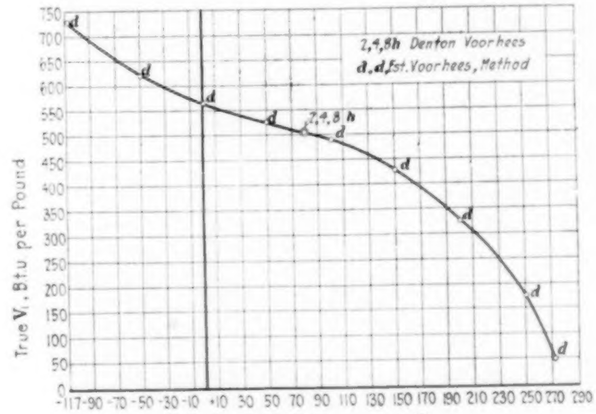


Fig. 11 True Latent Heat, Freezing Pt. to Critical Temp.

practical latent heat of ammonia-reproduced in Table 3. (*Ice and Refrigeration*, vol. 52, no. 4, April 1917, pp. 177-183, 3 figs., *etA*)

Safety Engineering

Glasses for Protecting the Eyes from Injurious Radiations, W. W. Coblentz and W. B. Emerson

The object of the present paper is to give the general characteristics of certain newly developed glasses sometimes used for protecting the eye from radiant energy, especially the infra-red or so-called heat rays. Because of the difficulty in reproducing the same color in different melts, no attempt is made to give specific data on the transmission for a given thickness of glass. In order to obtain exact data it is necessary to examine samples from each melt.

These data are representative of an extensive group of glasses available for protecting the eye from (1) the ultra-violet, (2) the visible and (3) the infra-red rays.

For protecting the eye from ultra-violent light, black, amber green, greenish-yellow, and red glasses are efficient. Spectacles made of white glass afford some protection from the extreme ultra-violet rays which come from mercury-in-quartz lamps, and from electric arcs between iron, copper, or carbon. The vapors from these arcs emit but little infra-red radiation in comparison with the amount emitted in the visible and in the ultra-violet rays.

For shielding the eye from infra-red rays deep black, yellowish-green, sage green, gold-plated, and bluish-green glasses are efficient. For working near furnaces of molten iron or glass, if considerable light is needed, a light bluish-green or sage-green glass is efficient in obstructing the infra-red rays. For working molten quartz, operating oxy-acetylene or elec-

tric welding apparatus, or other intense sources of light, it is important to wear the darkest glasses one can use, whether black, green (including gold-plated glasses) or yellowish-green, in order to obstruct not only the infra-red, but also the visible and the ultra-violet rays.

Data are given showing that of the infra-red rays emitted by a furnace heated to 1000 to 1100 deg. cent. (1) about 99 per cent are obstructed by gold-plated glasses, (2) about 95

TABLE 3 PRACTICAL LATENT HEAT OF AMMONIA

F°	r	F°	r	F°	r	F°	r	F°	r
−108	729	8	558	36	535	64	514	92	493
−100	709	9	557.5	37	534.5	65	513.5	93	492.5
− 90	687	10	557	38	534	66	513	94	492
− 80	667	11	556	39	533	67	512.5	95	491
− 70	650	12	555	40	532	68	512	96	490
− 60	635	13	554	41	531.5	69	511	97	489
− 50	622	14	553	42	531	70	510	98	488
− 40	608	15	552.5	43	530	71	509	99	487
− 30	597	16	552	44	529	72	508	100	486
− 20	585	17	551	45	528.5	73	507.5	110	476
− 10	575	18	550	46	528	74	507	120	465
− 9	574	19	549	47	527.5	75	506	130	454
− 8	573	20	548	48	527	76	505	140	441
− 7	572.5	21	547.5	49	526	77	504	150	426
− 6	572	22	547	50	525	78	503	160	409
− 5	570.5	23	546	51	524	79	502.5	170	391
− 4	569	24	545	52	523	80	502	180	371
− 3	568.5	25	544	53	522.5	81	501	190	350
− 2	568	26	543	54	522	82	500	200	328
− 1	567	27	542.5	55	521	83	499	210	305
0	566	28	542	56	520	84	498	220	280
+ 1	564.5	29	541	57	519	85	497.5	230	252
2	563	30	540	58	518	86	497	240	220
3	562.5	31	539	59	517.5	87	496.5	250	181
4	562	32	538	60	517	88	496	260	131
5	561	33	537.5	61	516.5	89	495	270	68
6	560	34	537	62	516	90	494	273	46
7	559	35	536	63	515	91	493.5		

per cent by sage-green or bluish-green glasses, (3) about 80 per cent by very-deep-black glasses, and (4) about 60 per cent by greenish-yellow glasses.

At higher temperatures these data would be somewhat different, but not sufficiently so to modify the rough estimate dealt with in this paper. (*Bureau of Standards*, Technologic Paper No. 93, November, 1916.)

Steam Engineering

ENERGY STORED IN A BOILER UNDER PRESSURE, F. R. LOW

An interesting discussion of the computation of the energy that would be released by an exploding boiler per pound of contained water and steam.

It is known that when steam separates from water out of which it is generated, a certain amount of work is necessary to overcome the atmospheric pressure. If the pressure per square foot be called p, and the difference in volume between that of the original water and the final volume of water and steam be called u, the pressure being in pounds per square foot, and the volume in cubic feet; if, further, the mechanical equivalent of heat be denoted by A, then the external work done in forcing back the environment when water changes to steam will be Apu (in foot-pounds).

The writer asks whether this Apu work should be included in calculating the energy released by a pound of water under the assumed conditions. There is no doubt that the Apu work is exerted upon the environing atmosphere, but pushing it back is all that it can do. Apart from that, any damage that is caused or any disturbance that is produced must be at the expense of other heat units. The Apu work in itself simply means the generation of a certain volume against the atmospheric pressure, so that as far as the computation of energy released is concerned, i.e., energy available for damage or disturbance, it would appear that the Apu work should not be included.

It makes a difference, however, how the case is stated, and *Power,* in its editorial work, has found such disagreement among authorities that it has asked a score or more of authorities what the value would be for 115 lb. absolute and 212 deg.

The writer presents the matter in the following way.

Imagine a pound of water heated to 338.1 deg. fahr. in a non-conducting cylinder and retained under 115 lb. per sq. in. absolute pressure by a diaphragm as in Fig. 12. Suppose the diaphragm burst. Further, assume that the cylinder, instead of being open as in Fig. 12, was closed at the top, with a partition, as in Fig. 14, the space between the partition and the diaphragm retaining the water being vacuous.

When the diaphragm broke, the mass of steam and water would be projected against the partition. But the partition and the containing wall are assumed to be non-absorptive and impervious to heat, and therefore the heat represented by the kinetic energy, the energy of motion of the projected mass, is reconverted by impact and eddying and friction into heat, and is applied to evaporating more of the water than as though it went off in the energy of flying masses. In this case the entire energy is available for evaporating water.

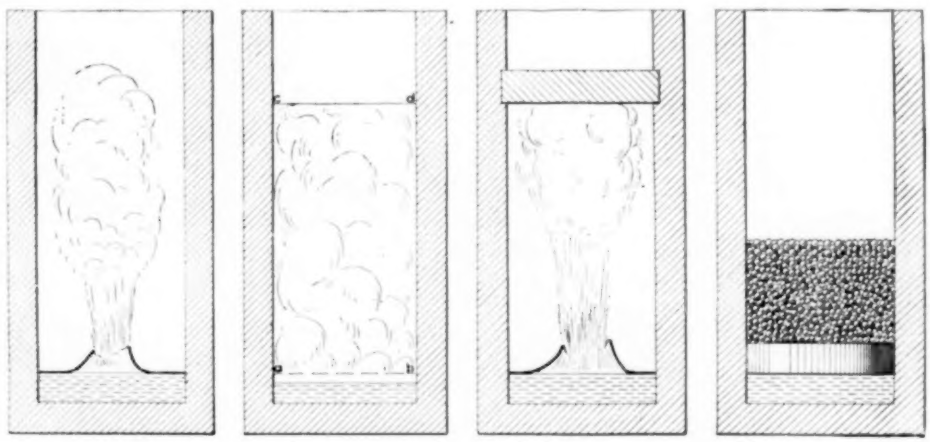
Let us imagine the case as shown in Fig. 15, in which a frictionless and weightless but still non-conducting piston over the liquid is loaded with, say, 100 lb. of shot per sq. in., with its area exerting upon the water the combined pressure of the shot and the atmosphere, 115 lb. per sq. in., and allowing it to be heated to 328.1 deg. without boiling. If now some of the shot is removed, the pressure will become less and the water will boil until, by evaporation, its temperature is reduced to the boiling point under the new pressure. When the shot is all removed, there will be only the atmospheric pressure upon the mixture, and the temperature will be 212 deg. Of the 309 B.t.u. in the pound of water at 115 lb., 180 are in the mixture of steam and water at 212 deg.; 8.87 are represented by the work of raising the piston against the atmospheric pressure, and the rest are consumed in making a part of the water into steam and lifting the shot.

The question raised by the author is whether the 8.87 B.t.u. used to push back the atmosphere is to be credited to the effective work of this steam. This question is answered in the following manner.

Imagine a pound of steam at 115 lb. to change places with an equal volume of free atmosphere. All that it can do is to expand, to generate energy equivalent to the portion of the pressure-volume diagram, Fig. 16, beneath the expansion line; the area $BCDEB$. The energy represented by $ABEFA$ was generated when the steam was made and is developed during the admission of this pound of steam into an engine cylinder or turbine nozzle by the simultaneous generation of an equal volume of steam in the boiler, pushing this one out; otherwise the pressure would not remain constant. A pound of steam changing places with an equal volume of free atmosphere can do none of this work; it can simply expand, and if the expansion is adiabatic or isentropic (that is, without the gain or loss of heat), the heat accounted for will be the same in the initial and final conditions.

The internal heat (that is, the difference between the total

heat and the heat equivalent of the *Apu* work) is given in the tables under the designation *E*, and since the action is by definition to take place without gain or loss of heat, the difference between these internal or intrinsic heat energies before and after expansion will be the heat equivalent of the work performed; that is, of the area *BCDEB*. For a pound of dry saturated steam at 115 lb., this is given by the table as 1106.5 B.t.u. After expansion, if it were still all steam, we could take the tabular value of *E* at the lower value away from 1106.5 and find the heat available for performing work. But during the expansion a part of the steam will have condensed and the quality and consequent internal energy will have to be computed.



Figs. 12 to 15 Methods of Change of Water, from 115 lb. and 338 deg. to Atmosphere and 212 deg.

The difference between the internal, or inherent, energies in the initial and final conditions, x_2 in this case being 0.885, is

$$E_1 - E_2 = 1106.5 - 974.34 = 132.16 \text{ B.t.u.}$$

This is represented by the area *BCDEB*. *Power* asked if the

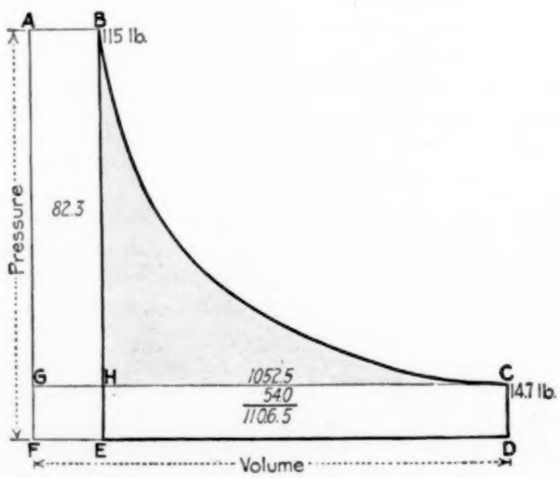


Fig. 16 *PV* Diagram for Steam

person addressed agreed that the energy released (that is, available to produce disaster and disturbance) is that represented by this whole area, or whether it should be reduced by taking out that represented by the area *HCDEH* (that is, the energy absorbed in pushing back the atmosphere with a pressure proportional to *CD* through a volume proportional to *ED*); in other words, whether for the case of the steam the energy available for damage and disturbance should be taken as that represented by the area *BCDEB* or by the shaded area *BCH*. (*Power,* vol. 45, no. 15, April 10, 1917, pp. 475-477, 6 figs. *t*)

Thermodynamics

Exhaustive Tests on Electric Water Heaters, Stanley V. Walton

The article gives details of tests of various types of electric water heaters. It is of considerable interest to mechanical engineers in view of the fact that incidentally valuable data were obtained on heat-transfer phenomena.

Among other things tests were run on heat-insulating materials, in particular, the so-called Economy boiler covering. This material consists of hair felt sewed up in canvas jackets, formed to fit a standard 30-gal. domestic boiler and held in position by lacing. A single-ply covering consists of a single jacket 1 in. thick. The three-ply covering consists of three separate concentric jackets applied one over the other. The magnesia was applied in the form of bricks to a total thickness of 2 in. with an outer cloth covering.

The purpose of the test was to determine radiation losses from the boiler alone, disconnected from all piping. For this purpose the boiler was insulated and filled with water which was heated approximately to the boiling point and the time-temperature curve in cooling was determined. From this curve and known quantity of water the radiation loss can be readily calculated. The results of the tests are given in Fig. 17.

Another test was run on uninsulated boilers, either bare or painted, and the results are given in Figs. 18-19.

A number of similar tests on heat losses from water piping, either bare or insulated, were run, the results being given in the form of curves. (*The Journal of Electricity,* vol. 38, no. 7, April 1, 1917, pp. 227-235, illustrated, *e*)

Varia

Intake Well at the Dubuque Electric Company's Plant, E. M. Walker

General description of the central power station at Dubuque, Iowa. This station has been recently reconstructed

and modernized without interruption of service and now has a generating capacity of 9500 kw.

An interesting feature of this station is an intake well shown in cross-section in Fig. 20. This station is located on a slough of the Mississippi River, about 2500 ft. away from the main river, and the supply of water for the condensers was a source of trouble for a number of years. The new well has provided a solution and removed the possibility of a scarcity of water at low stages of the river, which frequently occurs in midwinter and late midsummer.

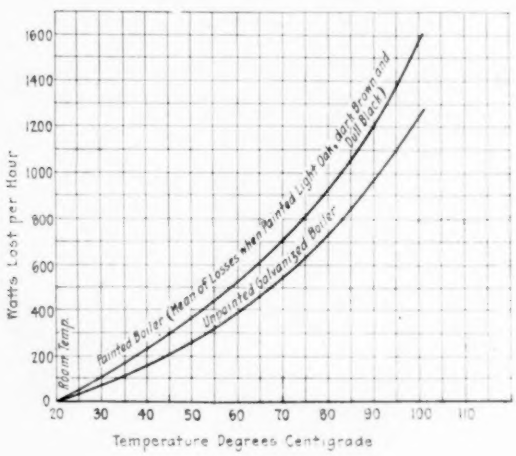


Fig. 17

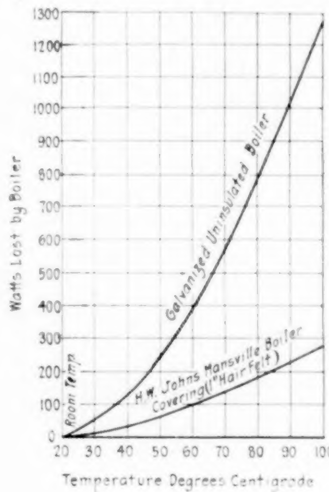


Fig. 18

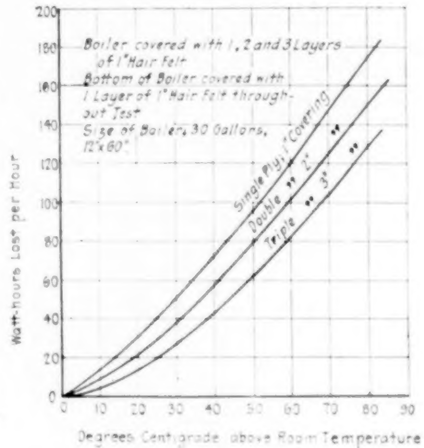


Fig. 19

FIG. 17 RADIATION LOSSES FROM BOILER. FIGS. 18 AND 19 HEAT LOSSES WITH UNINSULATED BOILERS

This well is designed to overcome the difficulty of low water, and also by the whirlpool action of the water in passing through the well to remove automatically a large percentage of the sediment in the river water. The well is built on the spiral principle, the water traveling around it many times, and thus allowing the sediment to settle into a sump in the center, from which it can be periodically removed by an ejector pump.

The well is 20 ft. in diameter and 36 ft. deep, the bottom

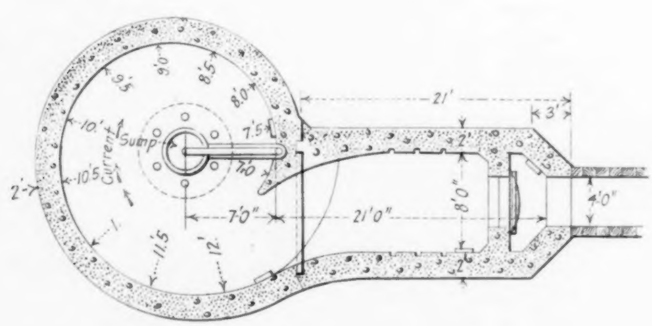


FIG. 20 CROSS-SECTION OF INTAKE WELL

being 6 ft. below zero stage of the river. The intake pipe is 36-in. flanged cast-iron. (*Electrical Review and Western Electrician*, vol. 70, no. 12, March 24, 1917, pp. 485-487, 6 figs., *d*)

RUSSIAN TESTS OF BRITISH TRUCKS, R. Douglas-Vickers

Some time last November the Russian Purchasing Commission in England arranged for trials of commercial vehicles, so as to give British makers an idea of the unusually severe conditions to be met with in Russia where roads are in most cases either poor or entirely absent.

All the vehicles submitted for the test had to carry a 30 per cent overload over an exceptionally poor stretch of ground. The heavy machines were unable to negotiate several stretches of very soft ground, while the lighter machines were better able to get over the difficult places.

It is believed that this test showed the British makers that, if the bad stretches of road referred to were anything like those which were commonly met in Russia, the Russian Commission was fully justified in calling for special requirements. These special requirements are as follows:

- More powerful engines
- Stronger frames and springs
- Greater clearance
- Larger wheels and twin tires on all rear axles for passenger cars
- Especially strong bodies
- Accessibility of all parts for repairs and simplicity to enable repairs to be effected without carrying a large amount of special material.

The writer believes that vehicles used on bad roads should not be of greater load capacity than 5000 lb., should drive on all four wheels, and if not, some means of locking the differential should be provided. (*The Commercial Vehicle*, vol. 16, no. 5, April 1, 1917, p. 23, *g*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer.

Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

SELECTED TITLES OF ENGINEERING ARTICLES

AERONAUTICS

Artillerie contre Avions. L'Aérophile, 25 Année, nos. 3-4, 1 & 15 Février 1917, pp. 63-64, 1 fig.
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Globe Alarm Check Valve. Model "D."
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NEW YORK CITY. Hall of Records Power Plant. Report and Discussion of Physical test and costs of operation and maintenance, test conducted in 1913, under the auspices of a Board of Engineers composed of representatives of the City of New York, The New York Edison Company and the New York Bureau of Municipal Research. *New York, 1916.* Gift of Municipal Reference Library.

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——— Wood using industries of New York. N. Y. State College of Forestry, Ser. XIV, no. 2.
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TWO OPPOSING RAILROAD VALUATIONS. Reprinted from the Unpopular Review, Jan-March 1917. Gift of Clemens Herschel.

UNIFORM SYSTEM OF ACCOUNTS FOR ELECTRIC RAILWAYS, PRESCRIBED BY THE INTERSTATE COMMERCE COMMISSION IN ACCORDANCE WITH SECTION 20 OF THE ACT TO REGULATE COMMERCE. *Washington, 1914.* Gift of Chas. H. Armstrong.

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VERMONT. State Geologist. Report, 1915-16. *Burlington, 1916.* Purchase.

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WHARVES AND PIERS. Their design, construction, and equipment. By Carleton Greene. *New York, McGraw Hill Book Co., 1917.* Purchase.

WICHITA, KANSAS. Financial Statement of City for 1911-1916. Gift of City Council.

WILKES-BARRE, PENN. Superintendent of Department of Accounts and Finance. Annual Report, 2d, 1915.
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Descriptive booklet of Acieral.

AMERICAN TYPE FOUNDERS CO. *Jersey City, N. J.*
ADCUTS. A new process for reproducing trade marks, signatures and all devices now being electrotyped.

BIRD, J. A. & W. & COMPANY. *New York, N. Y.*
Colonial Series no. 14-24. RIPOLIN Enamel Paint.

CHICAGO STEEL TAPE COMPANY. *Chicago, Ill.*
Descriptive booklet giving prices.

FAIRBANKS COMPANY. *New York, N. Y.*
Catalog No. 800. Trucks.

NATIONAL TUBE COMPANY. *Pittsburgh, Pa.*
"National" Pipe Standards appendix to 1913 Book of Standards.

TEXAS COMPANY. *New York, N. Y.*
Lubrication. *February 1917.*

UNDER-FEED STOKER COMPANY OF AMERICA. *Chicago, Ill.*
Publicity Magazine. *March 1917.*

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Catalogue 8-A. Westinghouse Electric Fans. *1917.*
Leaflet 1610. Auto-starters, Type A.
——— 3825. Electric Power Plants for the Oil Fields.
——— 3955. Direct Current magnetic contractor controllers for steel mill and crane service.
——— 3890. Elevator equipment in the Cleveland City Hall.
——— 3956. Direct current Magnetic Contractor Controllers for Steel Mill and Crane Service-Classification and Operation.

PERSONALS

IN these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary and items should be received by May 16 in order to appear in the June issue.

CHANGES OF POSITION

ANDREW C. LOUDON has accepted a position with the Locomotive Superheater Company, New York. He was until recently associate editor of the *Railway Age Gazette*, New York.

CHANNING TURNER, formerly assistant industrial engineer with the Winchester Repeating Arms Company, New Haven, Conn., has become ranch manager at Clearwater, Mont.

LEON P. ALFORD is now associated with *Industrial Management*, formerly Engineering Magazine, as editor-in-chief. He was editor of the *American Machinist* for about ten years.

RALPH S. BARNABY, formerly with The Elco Company, Bayonne, N. J., as inspector of material, has joined the engineering department of the Standard Aero Corporation, Plainfield, N. J.

ALBERT W. BISSELL has resigned as assistant sales manager of the American Refractories Company, Chicago, Ill., to enter the employ of the Colorado Fuel and Iron Company, Pueblo, Colo.

DAVID VAN ALSTYNE, until recently assistant to vice-president of the N. Y., N. H. and H. R. R., New York, has accepted a position with the American Locomotive Company, New York.

JOHN W. BRASSINGTON, formerly engineer with The Pusey and Jones Company, Wilmington, Del., has assumed the duties of chief engineer of the American Writing Paper Company, Holyoke, Mass.

CHARLES J. TEHLE has accepted a position with the Kerr Turbine Company of Wellsville, N. Y. He was until recently in the employ of the Chicago Pneumatic Tool Company of Franklin, Pa.

LA VERN J. CHARLES, until recently construction engineer with the U. S. Reclamation Service, Lakewood, New Mexico, has assumed the duties of assistant state highway engineer of Santa Fe, New Mexico.

FREDERICK A. OTTO, superintendent of the electrical department of the St. Paul Gas Light Company, St. Paul, Minn., has become affiliated with the Minnesota Gas and Electric Company, Albert Lea, Minn.

JAMES MCNAUGHTON has become affiliated with the Eddystone Ammunition Company, Eddystone, Pa., as assistant to the president. He was formerly vice-president of the American Locomotive Company, New York.

P. M. SMITH has resigned his position with the William Tod Company of Youngstown, O., to become connected with the Standard Engineering Company of Ellwood City, Pa., in the capacity of chief draftsman.

ANDREW WESTWATER, formerly marine engine and boiler draftsman with the Moore and Scott Iron Works, Alameda, Cal., has be-

come identified with the Columbia River Shipbuilding Corporation, Portland, Ore.

GILBERT I. VINCENT has accepted the position of engineer with the Syracuse Lighting Company, Syracuse, N. Y. He was until recently connected with the Des Moines Gas Company, Des Moines, Ia., in a similar capacity.

FORREST E. CARDULLO, formerly chief draftsman of the Pierce-Arrow Motor Car Company, Buffalo, N. Y., has assumed the duties of engineer of tests with the Curtiss Aeroplane and Motor Corporation of the same city.

FREDERIC C. HOLMGREN, material engineer with The Remington Arms Union Metallic Cartridge Company, Bridgeport, Conn., has assumed the duties of automobile expert with the Rock Island Arsenal, Rock Island, Ill.

HAROLD E. ROWE has left the employ of The Carborundum Company, Niagara Falls, N. Y., and has again become associated with The Sinclair Refining Company, with headquarters at their main office in Chicago, Ill.

EDWIN J. LANHAM, formerly employed as mechanical engineer for the Elyria Machine Company, Elyria, O., has recently become associated with the B. F. Goodrich Company, Akron, O., in the capacity of estimating engineer.

HERBERT R. LUCKE has resigned his position as manager of the De La Vergne Engine Company, Houston, Tex., to assume the duties of vice-president and assistant general manager of the Hughes Tool Company, Houston, Tex.

FRANK L. DALAS, formerly with the Youngstown Sheet and Tube Company, Youngstown, O., in the capacity of inspector of the electrical and mechanical department, has become head electrician at the Burma Mines, Burma, India.

ORLO L. WAUGH has accepted a position with The Crown Cork and Seal Company, Toronto, Ont., Canada. He was until recently employed by the Curtiss Aeroplane and Motor Company, Buffalo, N. Y., in the capacity of testing engineer.

THOMAS M. ROBERTS has resigned his position as electrical engineer's assistant, Interborough Rapid Transit Company, New York, and has become associated with the Navy Department, Bureau of Yards and Docks, Washington, D. C.

P. T. SOWDEN has resigned as works manager of the Torsion Balance Company, New York and Jersey City, to accept the position of assistant general manager of Arkell and Smith, Canajoharie, N. Y., manufacturers of paper bag machinery.

BRUCE M. SWOPE has accepted the position of assistant master mechanic of the Renovo Division of the Pennsylvania Railroad Company. He was formerly motive power inspector of the Pitcairn Car Shops of the same company, at Pittsburgh, Pa.

JOHN H. WYNNE has assumed the duties of vice-president of E. B. Cadwell and Company, Inc., New York. Mr. Wynne was formerly connected with the American Locomotive Company, New York, in the capacity of sales manager of construction equipment.

EDWIN FRANK, formerly instructor in mechanical engineering, University of Illinois, Urbana, Ill., has become affiliated with the C. H. Wheeler Manufacturing Company, North Philadelphia, Pa., in the capacity of centrifugal pump designer in the marine department.

R. J. S. PIGOTT, until recently associated with the Interborough Rapid Transit Co. in a consulting capacity, and for the last two years power superintendent of the Remington Arms and Ammunition Company, has become associated with the Sanford-Riley Stoker Company, New York, in a consulting capacity on power and service.

ANNOUNCEMENTS

E. C. HENN has been elected one of the directors of the Cleveland Chamber of Commerce.

SIR ROBERT A. HADFIELD has offered 200 pounds to provide for a prize for a new and accurate method for determining the hardness of various metals.

W. B. GREGORY, professor of experimental engineering, Tulane University of Louisiana, New Orleans, has been commissioned Major of the engineer section of the Officers' Reserve Corps.

JAMES G. SCRUGHAM, Dean of the Engineering College of the University of Nevada, Reno, Nevada, is to take a two years' leave of absence to accept the position of state engineer of Nevada.

PAUL M. LINCOLN, JACK S. HERBERT and ELMER K. HILES have received commissions signed by President Wilson, making them officers in the engineering division of the Officers' Reserve Corps of the United States Army.

PAUL C. PHILIPP has taken into partnership H. K. BEACH. Mr. Beach has had a wide experience along power plant work and general engineering for industrial concerns, especially designing of brass and copper mills. Mr. Philipp has been in private practice for a number of years, specializing in the valuation of public utility and industrial properties and preparing financial reports. The partnership will be conducted under the firm name of Philipp and Beach, with office headquarters at Philadelphia, Pa.

APPOINTMENTS

JACOB A. TEACH has recently been appointed mechanical engineer of the Minneapolis Steel and Machinery Company, Minneapolis, Minn.

AUTHORS

C. R. KNOWLES presented a paper on Railway Water Supply at the April 20 meeting of the New York Railroad Club.

JULIAN C. SMALLWOOD has contributed an article on Heat Balance of an Absorption Plant to the April 10 issue of *Power*.

HAROLD B. BERNARD has contributed an article on Natural-Gas Pumping Station at Roystone to the April 17 issue of *Power*.

DONALD A. HAMPSON is contributing a series of articles on The Tools of the Automobile Repair Shop to the *Horseless Age*.

GARDNER T. VOORHEES is the author of Latent Heat of Ammonia, which appears in the April number of *Ice and Refrigeration*.

CHARLES C. LYNDE is the author of Uniflow Steam Engine for Rod Mill Drive, which appears in the April issue of *The Blast Furnace and Steel Plant*.

CALVIN W. RICE and LEON GOLDMERSTEIN (Cammen) are the joint authors of an article on Mechanical Engineering in *The American Year Book*, 1916.

ALANSON P. BRUSH is the author of an article on Crankshaft Problems in Automobile Engines, which appears in the April number of *The Gas Engine*.

PAUL A. BANCEL has contributed a brief article entitled World's Two Largest Steam Hoists, to the April 7 issue of the *Engineering and Mining Journal*.

FREDERICK W. O'NEIL is the author of Recent Developments in the Design of Hoisting Engines, which appears in the April 7 issue of the *Engineering and Mining Journal*.

HENRY M. HOBART has contributd an article on Electrical Machinery Tests and Specifications Based on Modern Standards to the April issue of the *General Electric Review*.

ALLEN F. BREWER is the author of an article on The Principles of the Calculation of "Straight Line" Depreciation, which is published in *Industrial Management* for April.

P. C. IDELL presented an illustrated paper on Development of Boilers and Modern Boiler-Room Construction at the April 12 meeting of the Engineers' Club of Trenton, Trenton, N. J.

GEORGE W. FULLER has contributed to the April 5 number of *Engineering News-Record*, an article entitled Relations Between Sewage Disposal and Water Supply Are Changing, in which an appraisal of progress is made, viewed in the light of recent developments in the field of sanitary engineering.

W. D. FORBES is the author of Marine Machine Shop Equipment, published in the April issue of *Marine Engineering*. This article deals with tools ranging from the smallest and finest to the largest and heaviest required in shipyard machine shops.

Power Losses in Pneumatic Tires by E. H. LOCKWOOD, read before the January 25th meeting of the Pennsylvania Section of the Society of Automobile Engineers, was published in the February Bulletin of the Society of Automobile Engineers, and republished in the February Proceedings of the Philadelphia Engineers' Club, the February 1 issue of *The Automobile* and the March 31 number of *Automobile Topics*.

THE NEW BOOKS

All books received by The Journal will be listed under this heading, generally accompanied by brief descriptive notes. Works of special importance to mechanical engineers will be commented on at length by members and others peculiarly qualified by reason of their experience and training.

Riveted Boiler Joints. By S. F. Jeter, B.S.M.S., Member of Boiler Code Committee, Am.Soc.M.E., Chief Engineer, The Hartford Steam Boiler Inspection and Insurance Company. McGraw-Hill Book Co., Inc., New York, 1917. Cloth, 11 x 8 in., 52 figures and 75 full-page plates. $3 net.

The twofold aim of the author is to give a graphical treatment of riveted-joint design and to determine the best arrangement of rivets in a given joint. The graphical treatment is extensive and charts are given for nearly all diameters of rivets used in practice. The method of constructing additional charts is given should there be need for these in cases other than those given in the text. The best arrangement of rivets is attempted by the author, and is indicated by a statement rather than by proof. In this connection the chapter on Riveted Joints of Maximum Efficiency requires much polishing before the treatment becomes clear. The discussion refers mainly to lap joints, and the author does not state always whether the analysis is general or specific, thus leaving the reader to decide this question. If the book is intended for those who do not wish to undertake an intensive study, the previous criticism carries its maximum weight.

According to the author, the book is intended for boiler designers, boiler inspectors, students, and to some extent for structural engineers. For the latter class, however, the book seems to offer little, since structural engineers use rivets mainly in compressive members, and the joints subject to tension are rare.

The treatment is both analytical and graphical. The mathematics required of the reader consists of simple algebraic transformations and only a slight suggestion of analytic geometry. One accustomed to the use of cross-section paper will perhaps meet with little difficulty in plotting the linear equations given in the text. Moreover, the author works out a sufficient number of examples, so that the reader could hardly go astray, even though the explanations are extensive rather than explicit.

The graphical treatment is original, although it has been published previously by the author in the columns of *Power*. A discussion of limiting pitches is given, and this is a desirable asset.

The author does not devote any attention to the question of eccentrically loaded joints. In fact, lap joints are shown with the same prominence as double butt-strap joints with equal-width cover plates. Even the double butt-strap joints with unequal-width cover plates are shown, and these have the same disadvantages as the ordinary lap joints. It will be remembered that lap joints are going out of use rapidly, and in many states are prohibited by law. The reviewer concludes from the text that it makes little or no difference in the author's mind which are to be advocated.

Whether this book will be of service to the designer depends entirely on the designer's point of view. If one wishes to select joints with little or no calculation, the charts are of service. If, on the other hand, the designer prefers to calculate the joints from first principles, the book is of less service, since this part is not given with utmost clearness. One objection to the use of charts for boiler designers is that in drawing them the values of the resistances in tension, shear, and crushing must be fixed. Hence such charts would become obsolete should cases arise in the future when these values might be changed. They may be redrawn for the new values, however. This disadvantage does not hold for the analytical treatment.

Alphonse A. Adler.

Mechanical Equipment of Buildings.—Vol. I, Heating and Ventilation of Buildings. By Louis Allen Harding, B.S., M.E., and Arthur Cutts Willard, S.B. John Wiley & Sons, Inc., New York, 1916. Leather, 9¼ x 6½ in., 606 pp., 66 illustrations and charts. $4 net.

Volume I of this work deals with the heating and ventilating of buildings, and subsequent volumes will, it is said, relate to power plants, elevators, lighting systems, refrigerating plants, sprinkler systems, vacuum cleaning, and plumbing. The object of the authors is to produce a reference book for engineers and architects which will contain sufficient theoretical and commercial data for practical use in the designing room, and at the same time serve to show the student the relation between the theoretical principles involved and their practical application to actual problems. The various chapters cover the properties of water, steam, and air, the mechanics of their movement, heat transmission of building materials and of radiators, fuels and combustion, boilers, heating water in tanks and pools, chimneys, direct steam and hot-water heating, electrical heating, ventilation, warm-air furnaces, fan heating, air conditioning, temperature and humidity control, exhaust-steam heating, district heating, pipe fittings, valves, covering, the cost of equipment, and the preparation of plans and specifications.

While a great deal of information in the book is of value to the trained engineer, many of the rules given are so complex as to puzzle the average architect and the heating engineer without a thorough technical training. As a matter of fact, the work cannot help but impress one familiar with the subject that it will be of far more value in the classroom and in the hands of a technically trained engineer with the patience to digest the information contained in it, than it will be to the heating engineer that has graduated from the bench, and even the technically trained engineer seeking formulæ for his work that may be easily understood and easily applied. A great deal of the matter in the book has been taken from other sources. Much of the matter so obtained could have been omitted to advantage. In fact, one might well question the advisability of encumbering the book with tables of valve and pipe-fitting dimensions and the various dimensions of proprietary articles. As this information can be obtained from catalogues obtainable for the asking, it hardly seems fair for the purchaser of the work to pay for so much information that could be obtained elsewhere without cost. Again, there is a complete chapter on fuels and combustion. It would seem preferable to present instead a brief summary of the essential data required by the heating engineer and refer him for further information to the many excellent treatments of this subject in other books. In many cases a number of rules proposed

by different authors for solving the same problem are given, and it is to be regretted that their advantages and disadvantages and their limitations are not commented upon by the authors, for their presentation without such comment leads to perplexity in the mind of users of the book. The selection of rules given might here and there be improved. For instance, one finds no reference to the data on heat transmission through building substances, and to the rules for determining radiating surfaces as used by the late Alfred R. Wolff. When one considers the effect these data had on the science of heating in the United States, their omission in a work of this magnitude is to be regretted. This criticism should not obscure the fact that the work contains a great deal of very useful information, a most excellent and lavish selection of illustrations, and a good deal of matter that cannot be found in other works on the subject.

A MEMBER.

TO THE EDITOR:

The authors believe, in common with many other engineers, that the subject of heating and ventilation is of such commercial importance that a somewhat more comprehensive treatment is warranted than has thus far appeared.

This volume is now in use in many engineering offices, and from the reports the publishers and authors have received the method of treatment employed has apparently been justified.

The work is distinctly not a set of "Rules," and we are inclined to agree with the reviewer that the book was written for the man of technical training, or one who is acquiring such a training. Engineering subjects fortunately, perhaps, require some study to grasp, and this branch of engineering apparently is no exception to the rule.

Engineers in general, we believe, prefer to have the derivation of the formulæ and constants used stated in the text, rather than the bare statement of rules or formulæ. For this reason we have included such matter as our experiments on the heat transmission of building construction, which we believe are more complete, in many respects, than any heretofore published data in this connection.

The section devoted to hot-blast heating can hardly be reduced if one is to cover the subject properly.

Particular attention is directed to fan testing and the application of fan tables—a subject that comparatively few engineers are familiar with. This is the first treatise on the subject to include complete data on air washing and humidification, as well as a number of other subdivisions of heating.

THE AUTHORS.

Elementary Course in Lagrange's Equations. By N. W. Akimoff, Mechanical Engineer. Philadelphia Book Co., Philadelphia, Pa., 1917. Cloth, 6x9 in., 195 pp., 58 illustrations. $2.

In the preparation of this book the author had in mind to present the methods of analysis of Lagrange in such form that the average engineer might have a ready reference for the formulation of the fundamental problems of dynamics arising in engineering practice. It is therefore essentially a condensed selection of fundamental equations in dynamics, developed from foundational principles, and familiarity with the methods of the calculus and a ready interpretation of symbolic notation are essential to its reading.

The work is divided into five chapters which treat of the following subjects: Synopsis of principles of dynamics, 85 pp.; Lagrange's equations for a particle, 27 pp.; Lagrange's equations for a system, 31 pp.; Lagrange's equations for relative motion, 16 pp.; small oscillations, 35 pp. The method of treatment is quite similar to that found in the usual mathematical texts of this sort, in that the bases for the derivation of the several formulated relationships arrived at are certain general and fundamental concepts symbolically expressed, and the usual applications of the laws of numbers are resorted to in their treatment and transformation.

Aside from the references to the embodiment of certain dynamic problems in the case of the gyroscope, the automobile, and the balancing machine devised by the author, there are hardly any references to engineering practice illustrative of the problems dealt with. The treatment of the subject may therefore be characterized as academic. It would appear therefore that the main purpose of the book—to promote a use of Lagrange's method in the solution of dynamic problems—has been defeated. There never has been any lack of material of the sort this book contains. The difficulty does not seem to lie in this direction. Since the capacity to recognize in engineering problems certain fundamental principles needs more cultivation than the faculty of dealing with laws of numbers, it appears that the value of the book would have been enhanced for the engineer if more attention had been given to engineering problems. It is a simple matter for the student to learn that, given a beam of certain material, proportions, loading and methods of support, the moments and stresses arising are found "thus" and the relations are formulated "so." But one able to solve this sort of a problem is wholly at sea if given a machine and told to determine the nature and magnitude of the loadings of certain members, the rigidity of their support, the probability of maximum stress, where found and how much. This latter sort of text writing is rare and is very much needed.

The value of the book would be very much increased if there were a number of engineering applications given to illustrate the different problems. As it is, the engineer reading the book will naturally ask himself the question, "If this sort of analysis is so valuable for the solution of dynamic problems arising in engineering practice, why are there not some engineering problems given in illustration? It is hoped that in future editions the author will more intimately associate the purely mathematical with the engineering problem, and thus show engineers how this work of Lagrange may be used to a greater extent than it is today.

The book is well bound and neatly printed on good paper. The figures are clear and neatly made.

WALTER RAUTENSTRAUCH.

Fatigue Study. The Elimination of Humanity's Greatest Waste A First Step in Motion Study. By Frank B. Gilbreth, Mem.Am.Soc. M.E. and Lillian M. Gilbreth, Ph.D. Sturgis & Walton Company, New York, 1916. Cloth, 5x7½ in., 159 pp., 33 illustrations. $1.50.

This little book should be read by the president and directors of every industrial corporation, and copies of it should be presented to the superintendent of each department, with instructions to read it and then hand it to the foremen. A copy of it should be in every works library. "It is a good thing, pass it along." "Safety first" is the motto of every well-conducted factory: "fatigue study next" should be added to it.

Fatigue, the authors say, is a necessary by-product of activity. A little fatigue is easily overcome if proper rest is supplied immediately. Twice the amount of fatigue requires more than twice the amount of rest. Excessive fatigue requires a rest period that might have to be prolonged indefinitely. It is this fact that lies at the basis of the great unnecessary

waste in accumulated fatigue. Fatigue study is an attack upon this unnecessary waste. It aims: 1 To determine accurately what fatigue results from doing various types of work; 2 To eliminate all unnecessary fatigue; 3 To reduce the necessary fatigue to the lowest amount possible; 4 To provide all possible means for overcoming fatigue; 5 To put the facts obtained from the study into such form that every worker can use them for himself to get more out of life.

This book will outline a method of attack and furnish a working practice for attacking the fatigue problem in an industrial plant. "*What* has been done is worth while when we know *how* it has been done, and *why* it has been done." The authors discuss, in simple language that a child can understand, the what, the how, and the why of fatigue study and fatigue elimination. Fatigue elimination in a factory serves a double purpose. It makes money for the owner, by decreasing the waste of time which is caused by unnecessary fatigue, and increases the number of "happiness minutes" of the worker; and in order to begin fatigue study and fatigue elimination the best thing to do is to get the ideas that are so ably expressed in Mr. and Mrs. Gilbreth's little book. For those readers of the book who are not personally acquainted with Mr. Gilbreth, it may be well to state, what is not stated in the book, that the picture of the man in shirtsleeves examining the micro-motion film, is an excellent photograph of Mr. Gilbreth himself in one of his characteristic attitudes.

WM. KENT.

Oxy-Acetylene Welding. By C. W. Miller. The Industrial Press, New York, 1916. Cloth, 6x9 in., 287 pp., 192 illustrations. $2.50.

During the little more than ten years that oxy-acetylene welding and cutting of metals have been attaining importance as commercial industrial processes, considerable has been published concerning them. It has taken the form, however, for the most part of separate articles in the technical papers bearing on specific pieces of work that have been accomplished, or of the special forms of apparatus that have been developed from time to time for doing the work. The few books that have appeared have been rather limited in their scope as a rule or else lacking in detail when they attempted to cover the whole broad field.

The publisher of *Machinery* felt therefore that there was room for a comprehensive book on the art—entitled to a place in its Mechanical Library—and in compiling this Vol. XII of that series has supplemented what the author prepared with text and illustrations taken from miscellaneous articles previously printed in *Machinery*.

Mainly the purpose has been to make the work of practical utility to prospective users of the welding and cutting torches, and to that end highly scientific and technical treatment of the subject has been avoided. This intention appears to have been consistently adhered to, while at the same time enough has been included relative to the principles involved so that an intelligent understanding may be had of the functions of the apparatus and how to use it successfully.

As would be expected, the forepart of the book is elementary, describing the construction of the torches and the means for producing and storing the gases used. Then comes an account of the accessories desirable in a shop equipped for handling repair work, for this use of the process, rather than its application in manufacturing, comes more within the experience of the author. In fact, it would be difficult within the covers of any one book to deal adequately with manufacturing uses, since they are always more or less special and necessarily developed experimentally, hence no individual would be competent to discuss more than a limited field of such applications. If this were not so obvious it would be more an occasion of criticism that the title of the book does not indicate that it is practically confined to repair work.

One chapter embraces the contents thus far specifically alluded to, and the next nine deal with repair welding. A supplementary chapter describes the lead-burning process which, though much older and more familiar, is, after all, the original fusion-welding process; and finally, the last chapter takes up that distinctly different use of the oxy-acetylene torch, the cutting of metals by an oxygen jet actually burning its way through.

The section on repair work is the most valuable part so far as practical usefulness is concerned. It begins with the preparation of the work, which, being so essential to successful results, would have been better were it more fully treated. Expansion and contraction effects are referred to and directions given to allow for them in a few specific jobs, but since it is a lack of understanding the underlying principles of these effects and anticipating them with proper provisions that accounts for most of the failures in welded repairs, it would have added value to the book had there been a few well-chosen typical examples with illustrations explaining the fundamental principles of contraction in cooling. Knowing the whys and wherefores and when to look out for them, the reader could be put in position to work out his own problems as to the proper handling of almost any casting that he might be called upon to repair. It is a knowledge of just this element that makes the difference between a good and a poor welder.

On the matters of materials and fluxes and the obtaining of a properly adjusted neutral flame the discussion is excellent. The chapter on cast-iron welding which follows is also very commendable. It is one of the longest in the book, and justifiably so, for it deals with the most common class of repairs. Steel, malleable iron, copper, and copper alloys are metals less frequently welded, and one chapter suffices to cover the special precautions needful. Another whole chapter deals with that most difficult of metals, aluminum, and its extensive use in automobile parts makes skill in its repair a worth-while accomplishment.

Sheet-metal and plate welding, as of boilers, tanks, tubes, etc., is the nearest approach to manufacturing uses referred to and is sufficiently treated, considering the avowed scope of the book. Boiler welding is as yet not accepted as safe enough. State laws, insurance companies, and the A. S. M. E. Boiler Code forbid it. Probably it will not be countenanced until some trustworthy means is discovered for proving the integrity of a weld without testing it to destruction, when it is too late to put it in service, and we cannot be sure of duplicating results with what appear to be identical conditions. Tank welding, however, is usually permissible.

Some very useful general considerations are given in the last chapter of this section. They include such important subjects as unusual difficulties, qualifications and training of welders, care of apparatus, overhead costs, commercial limitations of the welding process, safety precautions in the use of apparatus, and other things that should be brought to the attention of the beginner to guard him against the pitfalls. A more than usually complete index is especially valuable in guiding the reader to those parts of the section on repair work where he will find the information needed for work in hand.

Assuredly, there is a field for such a book as this, and while it may not be perfect, nothing better of its kind has yet been brought out to the best knowledge of the reviewer.

HENRY R. COBLEIGH.